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M. P. KHAREGHAT MEMORIAL VOLUME

II

ASTROLABES

BY

M. P. Khareghat

Edited by Dinshaw D. Kapadia, M.A., B.Sc., I.E.S. (Retd.)

BOMBAY.

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THE SHAHNAMAH PRESS
No. 12, Karwar Street, Fort, Bombay, by Hosang T. Anklesaria,
Published by the Trustees of the Parsi Punchayet Funds and Properties,
Hornby Road, Fort, Bombay.

891.1081
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FOREWORD

This Foreword should have been written by a scholar qualified to assess the value and appreciate the merit of such a scientific work. But the task has devolved on me or rather has been thrust upon me because I happen to be the Chairman of the Editorial Board for the Muncherji Khareghat Memorial Volume.

Of the unpublished works of Muncherji the most erudite, the most unique, the most imposing and the most monumental was his "Astrolabe". The Editorial Board thought it should be edited by a scholar and scientist of high attainments and published along with the Memorial Volume. Fortunately, we found in Professor Dinsha Kapadia such a competent scholar and scientist, who kindly undertook to edit the work. All the illustrations which enhance the utility as well as the beauty of this volume are given by Prof. Kapadia, himself as silent and modest as Muncherji. In presenting the work so ably edited by him I shall only repeat what I have said in my sketch of Muncherji's life that "this feat of intellectual labour and learning is more than sufficient to make Muncherji live for years as an accomplished Avesta, Sanskrit and Persian Scholar, versed not only in religious and literary lore, but also in History, Geography, Numismatics, Astrology and Astronomy."

The Committee is deeply grateful to Prof. Kapadia for the labour of love devoted by him to the arduous task of editing so monumental a work.

16th January 1950 R. P. Masani.

INTRODUCTION.

It appears from the manuscripts of the papers as embodied in the accompanying essays, that about July 1925 late Mr. Muncherji Pestonji Khareghat, I. C. S. (retired) took up in his hands an examination and description of an Astrolabe given to him by Mr. J. B. Petit. Subsequently, about September 1925, he seems to have taken up similar work in connection with an Astrolabe in the Mulla Feeroze Library, the latter being about a hundred years more recent than the first one.

During the course of this work, it is but natural that he searched for and referred to papers already published previously on Astrolabes–as regards their description, their history, their varieties and their uses, as well as papers on cognate subjects like Astronomy, Astrology and mathematics all pertinent to the construction and use of Astrolabes. Information collected by him from various sources is gathered together in his manuscripts under consideration. It is surmised that Sheth Khareghat intended to revise and re-set these articles before being printed, but it appears that owing to his multifarious other pressing duties, he was not able to do so, and the manuscripts remained as originally copied out by him. Being thus of a disjointed character, an attempt has been made to arrange and systematize these papers and put them in order, so that a casual reader may appreciate their value and make some use of highly technical details in these papers. Whilst so doing, great care is taken to see that Sheth Khareghat's own work is not interfered with in any way: but whatever additional explanatory details were deemed necessary to be added, they are so given by enclosing them within [ ] square brackets. All matter, therefore, within square brackets is additional matter and Sheth Khareghat is not responsible for it.

Of the papers and articles referred to by Sheth Khareghat, in the preparation of his manuscripts, the principal ones may be mentioned as

(i) "Journal Asiatique", 9th Series, Vol. I, published in 1893;

(ii) "Journal Asiatique", 9th Series, Vol. XIII, published in 1896;

(iii) Encyclopaedia of Islam, Vol. I, published in 1913;
(iv) Lane's Arabic Lexicon;
(v) "Delhi Museum Astronomical Instruments"–published in 1921, by G. R. Kaye (No. 12, Memoirs of Archaeological Survey of India) - and designated in subsequent pages by D.M.A.I.;
(vi) "Astronomical Observatories of Jai Singh",-published in 1918, by G. R. Kaye (Vol. XL, Archaeological Survey of India, New Imperial Series) and designated by A.O.J.S.

Popularly, the Arabs are supposed to be the inventors and users of Astrolabes, a belief which has been shown to be erroneous by Sheth Khareghat, by his quotations from papers in Syriac of Sévère Sabokt, wherein he proves that the manufacture and use of Astrolabes was known to the Greeks long before the time when the Arabs sprang up into prominence by their literary and scientific activities (vide pp. 114-117). Sheth Khareghat however does not seem to have made much use of Arabic works on the subject and does not even to make a mention of the most important of the Arabic works–*Kitāb ut-Tafhim, Le–avāil-i-Ṣanā'at-ut-Tandjim* published by Ustād Abu Raihān Mohammad bin Aḥmad *Al-Birūni* in 420 A.H. (1029 A.D.) or briefly speaking *At-Tafhim* of *Al-Birūni.* Without a reference to this old classical work of Al-Bīrūni, much of the inspiration derived by the Arabs in the perfection of the Astrolabe becomes lost. The Arabic Edition of this work has its counterpart in Persian, and under the patronage of the Government of Iran, Aghā Jilāl Humāyī has recently published a printed edition of this memorable work in Persian with copious notes and intelligent commentaries in Khurshidi years 1316–1318. A Persian manuscript copy of this work is also in the Mulla Feeroze Library. Further, a fac-simile printed edition, with the original Arabic and its translation in English, page by page, by Prof. R. Ramsey Wright of the University of Toronto is published by Lusac & Co., London, in 1934. References have been given to this work, as well as to other Arabic and Persian Books, whenever deemed necessary to interpret some of the Astronomical and Astrological details as given on Astrolabes.

As regards, the country of manufacture of J. B. Petit astrolabe Mr. Khareghat conjectures that it is manufactured in Egypt (vide p. 3) but Mr. Khareghat's conjecture does not seem te be a good one when we take into consideration the other features of the Astrolabe. The words for Egypt and Egyptians occur only once on the instrument and those too are casual. The maker has given on the Astrolabe names of (i) 18 towns of Iran, (ii) 15 towns of India, (iii) 5 of Afghanistan, (iv) 8 of Eastern Turkestan, (v) 4 of Erak, (vi) 3 of Arabia, (vii) 2 of Syria, (viii) one general name Tibet, and (ix) one Miṣr (Egypt). The presumption is that if he was an Egyptian, he would naturally have given the names of several other towns of Egypt. He more probably seems to be a Sunni Mahomadan as he has scrupously omitted the names—Nadjaf and Kerbela—towns so dear to a Shiā', and given instead the name of Kufa, a town in ruins. As what Mr. G. R. Kaye, on p. 1, D.M.A.I. writes, there was a family of astrolabe makers at Lahore, and one Muhammad Muqim ibn 'Isā ibn Allahdād, Uṣṭūrlābī Humayūnī of Lahore made one instrument in A.H. 1053, and made another in A.H. 1070 which is in the British Museum. The maker of the Astrolabe under consideration is-one-Muhammad Zamān, al-Mundjam, al-Uṣṭūrlābī, as engraved on the Astrolabe, who made it in the year A.H. 1070.

This gentleman has shown a partiality by mentioning so many towns of India and not of Egypt; and that the very first name which he puts down in the inner circle of the ventre of the Astrolabe is Lahore, and the presumption is therefore stronger that-Muhammad Zamān al-Usturlābī, the maker of our Astrolabe, may be the same gentleman as the one who made the British Museum Astrolabe, as mentioned by Mr. Kaye.

In his descriptions of the Astrolabes and their Tablets, Mr. Khareghat refers to figures given by Mr. G. R. Kaye in his books previously mentioned. These books are now out of print and are only to be found in some Libraries. They are therefore not easily accessible. In order, therefore, to make the reader feel at ease, some figures are specially drawn (of course roughly) and referred to in the following pages. It is presumed that a reference to these figures will greatly facilitate clear understanding of the descriptions given by him. Figures have been attempted to be drawn with care and accuracy as far as possible, but not being a good draughtsman, apologies are to be tendered for obvious defects in them. All theoretical details for the constructions of these figures are omitted as they would be of too technical a character for an ordinary reader.

The instruments principally described in the following pages are (1) the Jehangir B. petit Astrolabe (designated hereafter as JBP Astrolabe), (2) the Mulla Feeroze Library Astrolabe (designated as MFL Astrolabe), and (3) the wooden Quadrant in the Mulla Feeroze Library. The other descriptions are derived from printed magazines and journals. The description of the Seville Astrolabe (which seems to be an interesting instrument) is also taken from journals and Mr. Khareghat does not seem to have seen the original instrument. The year of maufacture of the 1st JBP Astrolabe is A.H. 1070 (=A D. 1659-60), and that of the MFL Astrolabe is either A.H. 1160 (=A.D. 1747) or A.H. 1190 (=A.D. 1776-77) *i.e.* about 90 to 120 years afterwards; yet the JBP Astrolabe is more complete in details and is very accurately manufactured. The MFL Astrolabe though more modern, and attempted to be manufactured in an ornamental flowery style lacks in several details and appears to have been prepared with less care and is consequently less accurate. The wooden Quadrant is maufactured in A.H. 1136 (=A.D. 1723-24), and hence the date of its maufacture is intermediate between the dates of the two Astrolabes. The first JBP Astrolabe is therefore fully described and all possible supplementary information has been added to make the description more complete and self-explanatory.

All numbers engraved on the Astrolabes are in letters either single or compound according to the well-known Abjad notation. There are however two kinds of Abjad notation—(i) oriental and (ii) the occidental. Both are based on similar principles, but some letters have different values in the two systems. The one in common use is the oriental system: whilst in Western countries like Morocco, Algiers, Spain, the occidental one is in use. On the Astrolabes, examined by Sheth Khareghat, the oriental system is used throughout with or without dots: whilst on the Seville Astrolabe doscribed in section D, the occidental one is used (vide p. 84), and characters on it are generally Kufic. The oriental Abjad as used on the J.B. Petit and Mulla Feeroze Library astrolabes, may be briefly described as under.

Eight symbolic words, consisting either of 3 or 4 letters of the Alphabet, of which the first is (ابجد) abjad, are to be remembered in a particular order and each letter in order is assigned a value from 1 to 10, 20 to 90, and 100 to 1000 as under—

sa'afas	kaliman	ḥutti	hawaz	Abjad
سعفص	کلمن	حطی	هوز	ابجد
90,80,70,60	50,40,30,20	10,9,8	7,6,5	4,3,2,1

ḍazagha	*thakhadh*	qarishaṭ
ضظغ	ثخذ	قرشت
1000,900,800	700,600,500	400,300,200,100

Thus every letter has its numerical value, and numbers from 1 to 1999, can be easily put down: thus, for the number 1945, we have غ = 1000, ظ = 900, م = 40, and ه = 5, and any of the symbols involving these four letters غهمظ, مهغظ, هظمغ,...... ghahamẓ, mahghaẓ, hamzagh...represents the number 1945.

In the occidental system, the word سعفص (sa'afaṣ) is replaced by صعفض (s-a'afaḍ) قرشت by قرست and ضظغ by ظغش *i.e.*

س 60 is replaced by ص in occidental Abjad notation.
ص 90 ,, ,, ض ,, ,, ,, ,,
ش 300 ,, ,, س ,, ,, ,, ,,
ض 800 ,, ,, ظ ,, ,, ,, ,,
ظ 900 ,, ,, غ ,, ,, ,, ,,
غ 1000 ,, ,, ش ,, ,, ,, ,,

The symbol for 1000 is ا (alif) A also.

In order to facilitate reading of those numbers on the Astrolabes, a table is attached herewith of the principal numbers from 1 to 1000, to show how these numbers are generally represented, and how they are engraved on the Astrolabes. The letters on the Astrolabes are generally without dots, and they are in the usual Arabic characters. In the Seville Astrolabe they are in Kufic characters.

The full Tables of Contents, given separately, will clearly indicate the subject matter and the scope of these papers, as the original papers of Mr. Khareghat were mostly of a sketchy character and the exact import of which was not likely to be appreciated by the casual reader.

6, Staunton Road,
Poona 3rd September 1949. }

DINSHAH D. KAPADIA.

TABLES OF ABJAD NUMBERS

Number	Value in Letters	How engraved on the Astralobe	Number	Value in Letters	How engraved on the Astralobe	Number	Value in Letters	How edgraved on the Astralobe
1	ا	ا	21	کا	کا	41	ما	ما
2	ب	ٮ	22	کب	کٮ	42	مب	مٮ
3	ج	ح	23	کج	کح	43	مج	مح
4	د	د	24	کد	کد	44	مد	مد
5	ه	ه	25	که	که	45	مه	مه
6	و	و	26	کو	کو	46	مو	مو
7	ز	ر	27	کز	کر	47	مز	مر
8	ح	ح	28	کح	کح	48	مح	مح
9	ط	ط	29	کط	کط	49	مط	مط
10	ی	ے	30	ل	لہ	50	ن	ٮه
11	یا	ٮا	31	لا	لا	51	نا	ٮا
12	یب	ٮ	32	لب	لٮ	52	نب	ٮ
13	یج	ح	33	لج	لح	53	نج	ح
14	ید	د	34	لد	لد	54	ند	د
15	یه	ه	35	له	له	55	نه	ٮه
16	یو	ٮو	36	لو	لو	56	نو	ٮو
17	یز	ٮر	37	لز	لر	57	نز	ٮر
18	یح	ٮح	38	لح	لح	58	نح	ٮح
19	یط	ٮط	39	لط	لط	59	نط	ٮط
20	ک	ک	40	م	م مه	60	س	سه

Number	Value in Letters	How engraved on the Astralobe	Number	Value in Letters	How engraved on the Astralobe	Number	Value in Letters	How engraved on the Astralobe
61	سا	سا	82	فب	وں	155	قنه	فنه
62	سب	سں	83	فج	وح	160	قس	قسم
63	سج	سح	84	فد	ود	165	قسه	قسه
64	سد	سد	85	فه	وه	170	قع	قع
65	سه	سه	86	فو	وو	175	قعه	قعه
66	سو	سو	87	فز	ور	180	قف	قف
67	سز	سر	88	فح	وح	185	قفه	قفه
68	سح	سح	89	فط	وط	190	قص	قصم
69	سط	سط	90	ص	صم	195	قصه	قصه
70	ع	ع	95	صه	صه	200	ر	مر
71	عا	عا	100	ق	ق	205	ره	مره
72	عب	عں	105	قه	قه	210	رے	مرے
73	عج	عج	110	قے قی	قے	215	ريه	مريه
74	عد	عد	115	قيه	قيه	220	رک	مرک
75	عه	عه	120	قک	قک	225	رکه	مرکه
76	عو	عو	125	قکه	قکه	230	رل	مرل
77	عز	عر	130	قل	قل	235	رله	مرله
78	عح	عح	135	قله	قله	240	رم	رم
79	عط	عط	140	قم	قم	245	رمه	رمه
80	ف	ف	145	قمه	قمه	250	رن	مرنم
81	فا	وا	150	قن	قن	255	رنه	رنه

Number	Value in Letters	How engraved on the Astralobe	Number	Value in Letters	How engraved on the Astralobe	Number	Value in Letters	How edgraved on the Astralobe
260	رس	رسم	310	شي	شيء	360	شس	شسم
265	رسه	رسه	315	شبه	شيه	400	ت	تم
270	رع	رعم	320	شک	شک	500	ث	ثم
275	رعه	رعـه	325	شکه	شکه	600	خ	ح
280	رف	رف	330	شل	شلم	700	ذ	ذ
285	رفه	رفه	335	شاه	شله	800	ض	ضم
290	رص	رصم	340	شم	شمم	900	ظ	ط
295	رصه	رصه	345	شمه	شمم	1000	غ	غم
300	ش	شم	350	شن	شنم	0	ها	ہا , ها
305	شه	شه	355	شنه	شنه			

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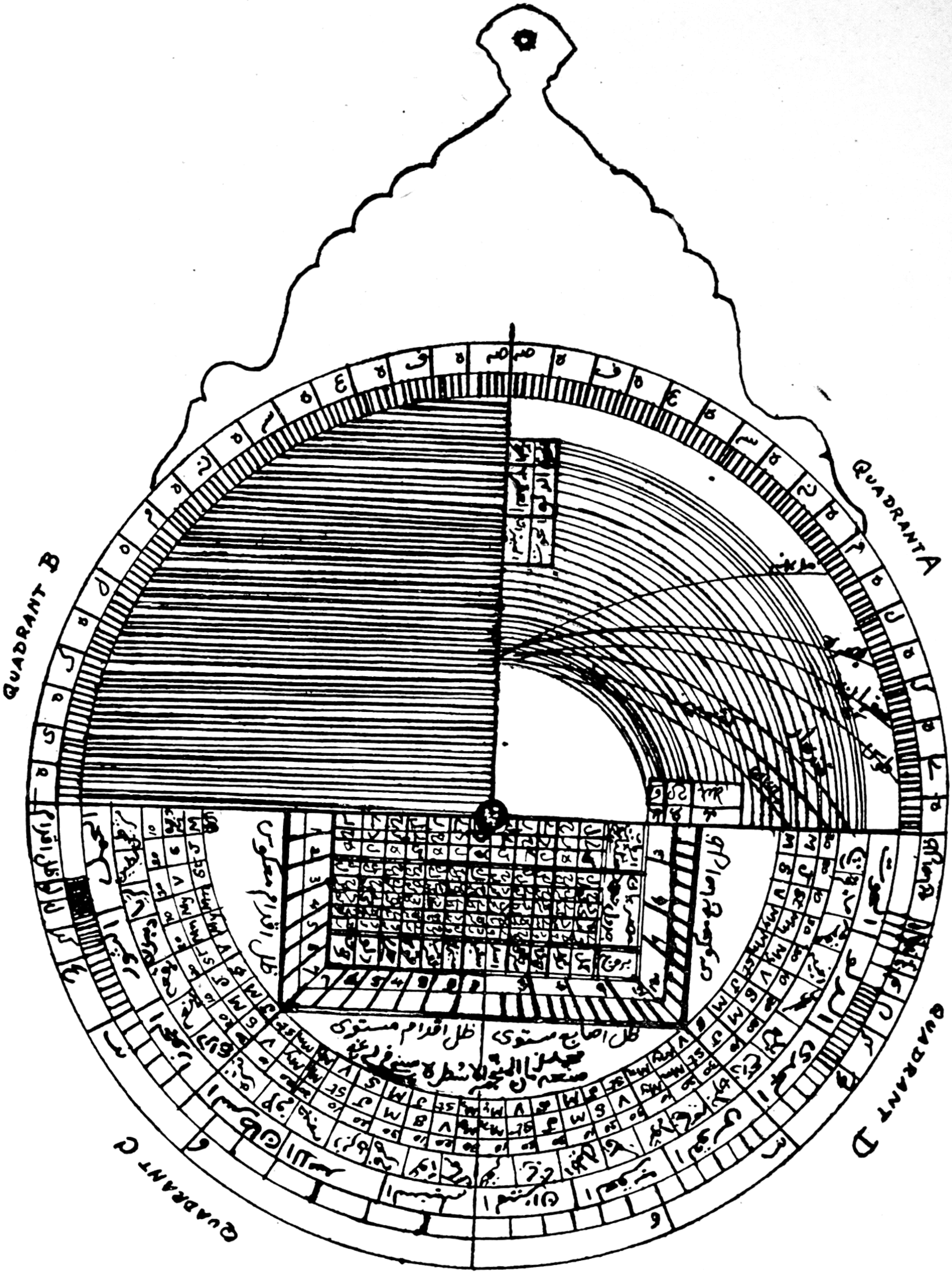


Fig. 1.—The Back of the JBP Astrolabe.

DESCRIPTION OF THE J. B. PETIT ASTROLABE

Notes about the Astrolabe given to me for examination by Mr. J. B. Petit on 3rd July 1925. The paper accompanying only gives the date 1070 H. and the name of the maker Muhammed Zamān, and a conjecture from the nature of the character that it may have been made in Egypt*. The other remarks are very general. [* Vide preface p. vii]

Real size and outline traced with a fine pencil. *See Fig. I*

The diameter of the whole plate is 5.1″ or 128 millimetres. Its thickness is .3″ or 7.5 Mm. Diameter of the central hole is 4½ Mm.

Ẓahr al-aṣṭurlāb (ظهر الاصطرلاب) (The Back of Astrolabe.)

Description of the Back.

The diameter of the first circle inscribed inside the outer margin is just equal to the full length of the revolving piece (Al'hiḍade, the dioptre) is 4.7″ or 119 Mm.

The diameter of the second inscribed circle which coincides with the 60 (parts) marked on the revolving piece is 4.5″ or 113.5 Mm. The upper edge of the revolving piece is 121 Mm., a little less than the diameter of the plate, and a little greater than the diameter of the first circles.

The Revolving Piece (Dioptre) العضادة (al'iḍāde)

See Fig. 2.

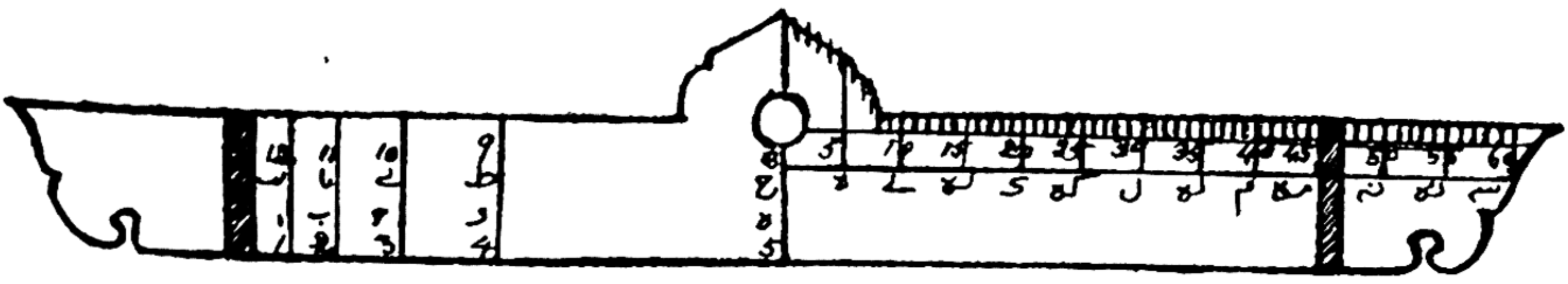
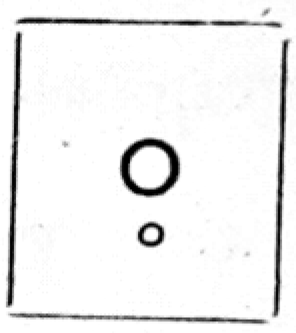


Fig. 2.—The Al'iḍāde (dioptre) of the JBP Astrolabe.

Total length 4.75″ or 121· Mm. Length from mark (of 60) to corresponding point on the other side which is not marked : 4.4″ or 113 Mm. Space between sights : 3.25″ or 82 Mm. The length of each mark on the upper edge would therefore be 4.5″/120 or 3″/80 or 114/120 Mm.

The breadth of the revolving piece inclusive of the bend is .45″ or 11 Mm.

Each sight is a square piece having its side equal to the breadth of the revolving piece (i. e. .45″) and fixed at right angles to the plane of the piece and has a small hole in the centre and another smaller one under it.



The revolving piece is bevelled above and from the centre *to the right* are marked the 60 parts by cuts, divisions of five parts being indicated above by the letters :

ه ے ىه ی که لہ له م مه نہ نه سہ
ه ے یه ک که ل له م مه ن نه س

i. e. 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60. The rod is not marked on the lower right side.

On the left, the bevelled edge is not divided, but the upper part of the rod is divided into five unequal parts decreasing from the centre upto the left as shown in the diagram above. The letters from the left to the centre are :

| یب | یا | ے | ط | ح i. e. ا, ب, ج, د, ه, ح, ط, ے, یا, یب,
| ا | ب | د | ی | ه

i. e. 1, 2, 3, 4, 5, 8, 9, 10, 11, 12.

The distances of the dividing lines from the left are respectively 3, 6½, 11, 19, 41 Mm.

[*Note* :—The tangents of 15° and its multiples 30°, 45°, 60° and 75° are .268, .577, 1, 1.732 and hence the above numbers are proportional to these five tangents, as can be easily seen by dividing these numbers by 11 (considering 11 as a unit) which gives the results .273, .590, 1, 1.73, 3.73.]

See Fig. I.— QUADRANT B.

The outermost margin (between the rim and the first inner circle) is divided into parts of 5° each marked respectively from the left horizontal diameter to the top by

ه ے ه ک ه ل ه م ه ن ه س ه ع
i. e. 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70,
ه ف ه ص
75, 80, 85, 90.

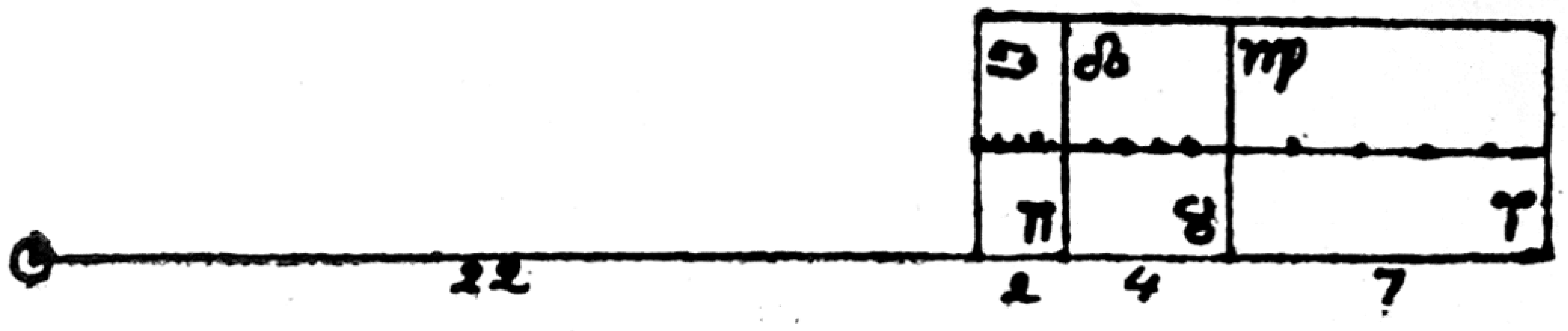
The second margin from the outside (between the first and second circles) is divided into 90 parts i. e. degrees of 1° each without any lettering or numbering.

The radius from the centre upto the top of the inner circle is divided into 60 equal parts exactly equal to the parts on the revolving piece and parallels to the horizontal diameter are drawn from each division on the radius upto the circumference. These lines are called خطہا ی جیوب khaṭhā-i-jayūb, lines of sines. Thus the Trigonometrical sine Jaib (Jib) جیب of any arc (Qaus) قوس on the circumference can be read off on the revolving diameter.

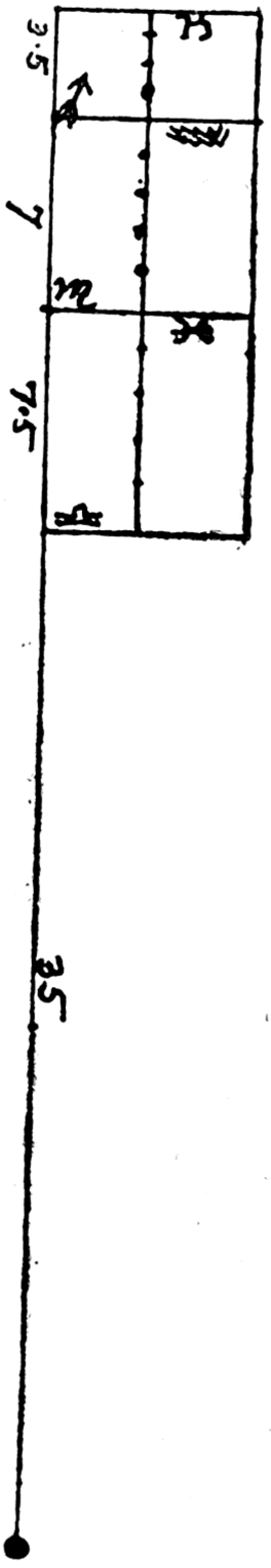
QUADRANT A.

The outer two margins in this Quadrant are marked in the same way as in Quadrant B, the first being divided into arcs of 5° numbered from the right horizontal diameter to the top and the second into 90 parts of a degree each.

The area of this Quadrant contains *declination circles* drawn as on the plates by stereographic projection, the radius of the circle representing the *Tropic of Cancer* being 23 Mm. or 24 parts; that of the *Equator* 35 Mm. or 38 parts, and that of the *Tropic of Capricorn* 54 Mm. or 57 parts. In a small rectangle along the horizontal (right radius) are given the names of the six northern signs of the Zodiac in two lines the names being the usual الحمل (al-ḥamal) *et cetera*, the circle corresponding to the beginning of (♈) *Aries* or the equator being 38 parts or 35 Mm.



in radius; that to the beginning of *Taurus* (♉) and end of *Leo* ♌ 28 Mm. or 31 parts, and that to the beginning of *Gemini* (♊) and end of *Cancer* (♋) 24 Mm. or 26 parts. (see fig. above enlarged about 2½ times.)



The six northern signs are shown in a similar rectangle along the vertical radius, the radius of the circle at the beginning of *Capricornus* (♑) and end of *Sagittarius* (♐) being 55 Mm; that at the beginning of *Aquarius* (♒) and end of *Scorpio* (♏) 49.5 Mm. and that at the beginning of *Pisces* (♓) and end of *Librā* (♎) being 42.5 Mm.; and that at the end of *Pisces* (♓) and beginning of Libra (♎) 35 Mm. (see fig. aside enlarged about 2½ times.)

No declination circles more northerly than the Tropic of Cancer are marked. All the signs except ♊, ♋, ♑, ♐ are divided into five parts, a declination circle marking the limit of each; the signs ♊, ♋, ♑ and ♐ are divided into 4 parts, the circles being correspondingly nearer. Thus there are altogether 28 parts and 29 circles, corresponding to about 23°½N, 23°¼N, 22°½N, 21°⅔N, 20°⅕N; 19°N, 17°¼N, 15°½N, 13°½N, 11°½N; 9°⅓N, 7° N, 4°¾N, 2°⅓N, 0°; 2°⅓S, 4°¾S, 7°S, 9°⅓S, 11°½S; 13°½S, 15°½S, 17°¼S, 19° S, 20°⅕S; 21°⅔S, 22°½S, 23°¼S, 23°½S—of Declination. It may be mentioned passingly that these declination circles can be made use of to determine the declinations of the stars on the *'ankabūt*, mentioned hereafter. But as

(a) these circles are not for equal differences of declination and (b) the circles for latitudes higher than 23°½ N and 23°½ S are not drawn, not much use can be made of these. To determine the declination of stars on the 'ankabūt', a disc like the one mentioned hereafter is convenient. (vide fig. 6)

Besides the declination circles and names of signs there are seven curves probably arcs of circles connected with the names of 7 towns viz. ملتان (Multān), کشمیر (Kashmir), قندهار (Qandahār), طوس (Tūs), اصفهان (Iṣfahan), بصره (Baṣrah) and مدینه (Madinah). I cannot say at present what these curves indicate. [vide note* below the next para]. These curves may be described as follows :—

The *Multān* Curve begins in the horizontal radius 40 Mm. from the centre, cuts the equator at 14° measured along the edge of the quadrant and the tropic of Cancer at 70°. The *Kashmir* curve begins at 46 Mm. (declination 15° 28′ S) from the centre, cuts the equator at 24° and Tropic of Cancer at 65°. The *Kandahār* curve begins at 50 Mm. (declination 20° S) from the centre, cuts the equator at 35° and the Tropic of Cancer at 80°. The *Tūs* curve begins at the circumference of the main circle at 9°, cuts the equator at 44° and the Tropic of Cancer at 75°. The *Isfahān* curve begins at the circumference of the main circle at 11°, cuts the equator at 50° and the Tropic of Cancer at 85°. The *Busra* curve begins at the circumfereece of the main circle at 22°, cuts the equator at 54° and the Tropic of Cancer at 84°. The *Madina* curve begins at the circumference of the main circle at 32°, cuts the equator at 62° and the Tropic of Cancer at 90°.

. *[These curves represent the Altitudes of the Sun at the several places, when the Sun crosses the Azimuth of Mecca ; vide Prof. Wright's translation of Arabic edition of Albiruni's At-tuhfim, p. 195].

QUADRANTS C & D.

The outermost margin in a semicircle corresponding to the outermost margins of Quadrants A and B contains a circular scale of shadows. In the Quadrant C, they are called zill-i-aqdām (ظل اقدام) "shadows in feet"; they are uumbered respectively from bottom to left و, یب, یح, کد, ل, لو, i.e. 6, 12, 18, 24, 30, 36; the shadow 6 being at 49° from the horizontal diameter downwards 12 at 30°½, 18 at 21°, 24 at 16°, 30 at 13°, and 36 at 11°. They represent the horizontal shadows of a vertical gnomon 7 feet high, when the sun is at the respective altitudes.

In a similar way, in the quadrant D in the outer-most margin the shadows are called zill-i-aṣābi‘a (ظل اصابع) " shadows in fingers or digits"; they are numbered respectively from bottom to top
و, يب, يح, كد, ل, لو, مب, مح, ند and سه
i. e. 6, 12, 18, 24, 30, 36, 42, 48, 54, and 60, being respectively at the following degrees from the horizontal diameter downwards 64°, 45°, 34°, 26°½, 22°, 18°, 16°, 14°, 12½°, 11½°. They represent the horizontal shadows of a vertical gnomon 12 fingers high.

In the *second* semicircular margin each of the outer parts which are in groups of 6 are divided into 6 parts although not numbered; thus each division in the left quadrant corresponds to a foot, and in the right to a finger's length.

[The Terms اصابع (aṣābi‘a) and اقدام (aqdām), though they literally mean "fingers or digits" and "feet" respectively, they are really speaking technical terms, which Mr. MPK. perhaps does seem to have noticed. They are here used in connection with the gnomon stick which is called in Persian شخص (shakhṣ) by the lengths of whose shadows at the various altitudes of the sun, a scale is obtained exactly equivalent to modern Trigonometrical Tangent scale. In this connection the following extracts from Al Biruni make things quite clear—

227. *A gnomon and its shadows.*

"The style, called شخص (shakhs) may be made of wood or "other material sharpened at each end and driven like "a peg perpendicularly into the ground. When the sun is "out, the shadow of the style with its divisions is "measured to see how they compare. The line joining "the point of the style and the point of the shadow is "called the diameter (hypotenuse) of the shadow قطر الظل "quṭr al-zill)."

228. "If the style is divided into 12 equal parts these are "named اصابع (aṣābi‘a) or fingers; if into sixty, divisions, "اجزاء (ajzā’), and if into seven, feet اقدام (aqdām). (Some people use 6½ for the last)."

229 "There are two kinds of shadows—the one cast on a "horizontal, and the other on a vertical surface, when

"*e. g.* the gnomon is fixed perpendicular to a wall; the "former shadow is called مستوی (mustawi) (*umbra recta*) "while the latter is named منتصب (muntaṣib) on account "of being perpendicular to the ground, and is also called "معکوس (ma'kūs), because the point of the shadow is directed "to the ground, head downwards (*umbra versa*)."

vide—Arabic edition of "Kitāb-ut-tahfim", translated by Prof. R. Ramsay Wright, 1934, p. 133; Al-Birūni, Tfhm, pp. 182-183.

These paras quoted here are quite explicit and show that divisions of any linear measure into 12, 60 or 7 equal parts are technically known as aṣābi'a, ajzā', and aqdām.

Now as the length (1) of shadows of a vertical gnomon at various altitudes of the sun, are given by the formula $l = h \tan z$, or $h \cot \alpha$, where z is the zenith distance, and $\alpha = 90\text{-}z$ altitude, of the Sun and h the length of the gnomon stick; which in the case of aṣābi'a is 12 units and in the case of aqdām 7 units.

Hence in the above quoted para on ظل اقدام (zill-i-aqdām) where the gnomon is divided into 7 parts, $\tan 10^\circ = \frac{7}{36}$, $\tan 13^\circ = \frac{7}{30}$, $\tan 16^\circ = \frac{7}{24}$, $\tan 20^\circ = \frac{7}{18}$, $\tan 30^\circ = \frac{7}{12}$ and $\tan 49^\circ = \frac{7}{6} = 1.166$, and when as stated above, the dioptre (al'idāde) of the Astrolabe points to 6, 12, 18, 24, 30, and 36, divisions for altitudes 49°, 30°, 21°, 16°, 13° and 11°, we have $7 = 36 \tan 10^\circ = 30 \tan 13^\circ = 24 \tan 16^\circ = 18 \tan 20^\circ = 12 \tan 30^\circ = 6 \tan 49^\circ$; and in the para on ظل اصابع (zill-i-asābi'a), where the length of the gnomon is divided into 12 parts, we have.

$$\tan 11\tfrac{1}{2}^\circ = \frac{12}{60} = .2\,; \quad \tan 18^\circ = \frac{12}{36} = .333\,; \quad \tan 34^\circ = \frac{12}{18} = .666\,;$$

$$\tan 12\tfrac{1}{2}^\circ = \frac{12}{54} = .222\,; \quad \tan 22^\circ = \frac{12}{30} = .4\,; \quad \tan 45^\circ = \frac{12}{12} = 1\,;$$

$$\tan 14^\circ = \frac{12}{48} = .25\,; \quad \tan 26^\circ = \frac{12}{24} = .5\,; \quad \tan 64^\circ = \frac{12}{6} = 2\,;$$

i. e. we have $12 = 60 \tan 11\tfrac{1}{2}^\circ = 54 \tan 12\tfrac{1}{2}^\circ = 48 \tan 14^\circ = 42 \tan 16^\circ = 36 \tan 18^\circ = 30 \tan 22^\circ = 24 \tan 26\tfrac{1}{2} = 18 \tan 34^\circ = 12 \tan 45^\circ = 6 \tan 64^\circ$.

Thus in the aqdām scale 7 divided by the shadow-length given on the arc gives the tangent of the angle measured from the horizon to the pointer and similarly in the aṣābiʿa scale 12 divided by the shadow-length gives the tangent of the angle measured similarly. These scales of aqdām and asābiʿa, together with the scale of jaib (sine scale) as given in quadrant B, enable us to solve the ordinary trigonometrical problems of the measurements of heights and distances. vide notes on pp. 134-136 also tables of tangents are given with explanation in our author's article on "Notes from Journal Asiatique, 1893, pp. 104-106]

The *third to seventh semi-circular margins* of both quadrants are continuous.

The *third margin* is divided into 12 equal parts of 15° each, each containing the name of one of the zodiacal signs beginning with Aries (♈) Al Ḥamal (الحمل) from the left, and ending with Pisces ♓ (الحوت) Al-Ḥut at the right. (see Tables below).

The *4th semi-circular margin* is divided into 28 equal parts each containing the name of one of the Arab Manāzils منازل (Lunar Mansions or asterisms) beginning from the left with شرطين (sharaṭin) and ending with رشا (rishā) at the right (see Tables below).

The 5th margin is divided into 36 equal parts, every group of three corresponding to each zodiacal sign being marked respectively ل ، ك ، ے i. e. 10, 20, and 30 for each sign.

The *6th semi-circular margin* is divided into 36 equal parts called وجوه (wudjūh) (pl. of وجه wadjah, face, aspect) evidently corresponding to each of the three divisions of a sign, of 10° each; they are marked in succession from the left ی ، ه ، سه ، ح (possibly د), ر ، ل ، ے the letters denoting Mars, the Sun, Venus, Mercury, the Moon, Saturn and Jupiter respectively; they are repeated five times in the same order, the series ending with ح (Mars).

The *7th margin* is also divided into 36 equal parts called اردجان (ardajān); they are marked in succession from the left ح, ے , ل, ر, ی , ه , سه i. e. Mars, Jupiter, Saturn, the Moon, Mercury, Venus and the Sun. They are repeated five times and end with ح (Mars). Evidently they are the same planets as those in the 6th margin, but in a reverse order.

It is necessary to point out at this stage that on this Astrolabe, as is the usual practice amongst the Arabs and the Persians, the names of the seven Planets are designated by the last letters of the words expressing them as under :—

(i) The Sun شمس (shams) by س (سه on this astrolabe).
(ii) The Moon قمر (qamar) by ر
(iii) Mercury عطارد' (‘auṭārad) by د (ى on this astrolabe).
(iv) Venus زهره' (zuhrah) by ه
(v) Mars مرّيخ (mirrikh) by خ (ح without dot)
(vi) Jupiter مشترى' (mushtari) by ے
(vii) Saturn زحل' (zuḥal) by ل

[This notation is both convenient and un-ambiguous. Hindus in general adopt the first letters of the words of their names. In Europe the symbols — ☉, ☾, ☿, ♀, ♂, ♃, ♄ are used to denote these planets.

The additional Technical terms, وجوه (wudjūh) and اردجان (ardajān) mentioned in the 6th and the 7th semicircular margins require some explanation to understand their purpose.

وجوه (wudjuh) (pl. of وجه wadjah, an aspect) are Decans (portions of 10° each), otherwise known as Aspects or Faces. “They are the Divisions of Zodiac each into 3 divisions of 10° each. Each division of time has its own protecting Genius or Chronocrator, and 36 Decans are possibly of such or religious origin and correspond to 36 protecting Divinities.”—Kaye, A. O. J. S., p. 123.

According to Al-Bīrūnī, Tfhm, p. 403—“Each group of 3 divisions of a zodiacal sign is called a وجه (wadjah) or بهر (bahar), and each one of them is of 10°. But their ruling Lords, according to the practice in vogue amongst Pārsiyāns and Rumiyāns, is such that the Lord of the first وجه (wadjah) of Aries is Mars, of the second wadjah—the Sun, and of the third—Venus. The Lord of the first wadjah of Taurus is Mercury, of the second—the Moon, and of the third—Saturn. The Lord of the first wadjah of Gemini is Jupiter, of the second—Mars, and of the third—the Sun, and so on in this order.”

اردجان (ardajān) are generally the reverse of the wudjūh, but do not seem to be very much in use. According to Agha sayyad Mahamadali in his فرهنگِ نظام (Farhang-i-Nizām) it is a sort of astrological table out of the large variety of tables in use in astrological predictions.

Agha Jelāl Humāyi, the Editor of Albirūnī's Kitāb-ut-tafhim in a note on p. 404, remarks as under

" اردجان (ardajān) has also some relationship between the planets and zodiacal Houses, like 'Drikkāna' (also 'Trikāṇna') and the author of 'Kifāyat-ut-ta'ālim', writes in his treatise that the rule about ardajān is this that the first of Aries is assigned to Mars, the second to Jupiter and the third to Saturn. The fourth which is the first of Taurus is assigned to the Moon, and so on in this manner according to the order of signs in the heavens. But these اردجان (ardajān) are in an order reverse of that of wudjuh: for this reason that the dispositions of wadjah are from the height of heavens to downwardness whilst those of ardajān are from downwardness to the height of the heavens."

That اردجان (ardajān) are in the reverse order of the وجوه (wudjūh) seems to have been noted by late Mr. M.P. K. as mentioned above.

Kaye A. O. J. S., P. 123 has arranged these وجوه (wudjūh) in three vertical columns for the zodiacal signs in succession, and shows that the decans read vertically are in the order of the *days of the week*, and also in the same order from the bottom of the first column on to the top of the next.

اردجان (Ardajān) Tables when similarly placed in columns, also show that they are in the order of the days of the week, but from bottom upwards, and from the top of the third column to the bottom of the second and so on, obviously so, as they are the reverse of the وجوه (wudjūh). The following table will show this at a glance.

بروج Constellation	وجوه و خداوندان شان (wudjūh) Decans and their Lords.			اردجان و خدوندان شان (ardajan) and their Lords.		
	ے =10:	ك = 20	ل = 30	ے = 10:	ك = 20 :	ل = 30
حمل Aries	ح Mars	س Sun	ه Venus	ح Mars	خ Jup.	ل Saturn
ثور Taurus	د Merc.	ر Moon	ل Sat.	ر Moon	د Merc.	ه Venus
جوزا Gemini	ے Jup.	ح Mars	س Sun	س Sun	ح Mars.	ے Jup.
سرطان Cancer	ه Venus	د Merc.	ر Moon	ل Sat.	ر Moon	د Merc.
اسد Leo	ل Sat.	ب Jup.	ح Mars	ه Venus	س Sun	ح Mars
سنبله Virgo	س Sun	ه Venus	د Merc.	ے Jup.	ل Sat.	ر Moon
میزان Libra	ر Moon	ل Sat.	ے Jup.	د Merc.	ه Venus	س Sun
عقرب Scorpio	ح Mars	س Sun	ه Venus	ح Mars	ے Jup.	ل Sat.
قوس Sagitta.	د Merc.	ر Moon	ل Sat.	ر Moon	د Merc.	ه Venus
جدی Capricorn.	خ Jup.	ح Mars	س Sun	س Sun	ح Mars	ے Jup.
دلو Aquarius	ه Ven.	د Merc.	ر Moon	ل Sat.	ر Moon	د Merc.
حوت Pisces	ل Sat.	ے Jup.	ح Mars	ه Ven.	س Sun	ح Mars
	to the top of the next column →	to the top of the next column →		From the top of the last column ↑	From the top of the last column ↑	
	ے = 10	ك = 20	ل = 30	ے = 10	ك = 20	ل = 30

The various Tables given in the semi-circular margins from the 3rd to the 7th can be tabulated as under. It is to be noticed that as each constellation is equal to $2\frac{1}{3}$ Lunar mansions, and 30° and 3 (وجوه) wudjūh and 3. (اردجان) ardajān, the figures on the astrolabe are so drawn as to show their correspondence. Similar attempt is made in the following tables :—

3rd circle بروج Zodiacal Sign	4th circle منازل قمر Lunar mansions	5th circle درجه Degrees	6th circle وجوه و خداوندان شان Decans and their Lords	7th circle اردجان و خداوندان شان Ardajāns and their Lords
1. الحمل Al-Ḥamal Aries	1. شرطين Sheratyin	ے 10	ح Mars	ح Mars
	2. بطين Buṭayin	ك 20	س The Sun	ے Jupiter
		ل 30	ه Venus	ل Sat.
2. الثور Al-Thaur Taurus	3. ثريا Thurrayā	ے 10	د Merc.	ر Moon
	4. دبران Dabaran	ك 20	ر Moon	د Merc.
	5. هقعه Haqa'ah	ل 30	ل Saturn	ه Venus
3. الجوزا Al-Jauza Gemini	6. هنعه Hana'ah	ے 10	ے Jupiter	س Sun
	7. ذراع Ḍharrā'	ك 20	ح Mars	ح Mars
		ل 30	س Sun	ے Jup.
4. السرطان As-Sartan Cancer	8. نثره Natharah	ے 10	ه Venus	ل Sat.
	9. طرفه Tarafah	ك 20	د Merc.	ر Moon
	10. جبهه Jabahah	ل 30	ر Moon	د Merc.
5. الاسد Al-Asad Leo		ے 10	ل Sat.	ه Venus
	11. زبره Zubarah	ك 20	ے Jup.	س Sun
	12. صرفه Surfah	ل 30	ح Mars	ح Mars.
6. السنبله Al-Sumbale Virgo	13. عوا 'Awwa	ے 10	س Sun	ے Jup.
		ك 20	ه Venus	ل Sat.
	14. سماك Simāk	ل 30	د Merc.	ر Moon

3rd circle بروج Zodiacal Sign	4th circle منازل قمر Lunar mansions	5th circle درجه Degree	6th circle وجوه وخداوندان شان Decans and their Lords	7th circle اردجان وخداوندان شان Ardajāns and their Lords
7. الميزان Al-Mizān Libra	15. غفر Ghafara	ی 10	ر Moon	د Mercury
	16. زبانا Zabānā	ك 20	ل Sat.	ه Venus
		ل 30	ی Jupt	س Sun
8. العقرب Al-‘Akarab Scorpio	17. اكليل Iklil	ی 10	ح Mars	ح Mars
	18. قلب Qalb	ك 20	س Sun	ی Jup.
	19. شوله Shūlah	ل 30	ه Venus	ل Sat.
9. القوس Al-Qaus Sagittarius	20. نعائم Na‘ayim	ی 10	د Merc.	ر Moon
		ك 20	ر Moon	د Merc.
	21. بلده Baldah	ل 30	ل Sat.	ه Venus
10. الجدی Al-Jaddi Capricorn	22. ذابح Dhābaḥ	ی 10	ی Jup.	س Sun.
	23. بلع Bula‘a	ك 20	د Merc.	ح Mars.
		ل 30	س Sun	ی Jup.
11. الدلو Al-Delv Aquarius	24. سعود Sa‘aūd	ی 10	ه Venus	ل Sat.
	25. اخبيه Akhbayah	ك 20	د Merc.	ر Moon
	26. مقدم Muqqadam	ل 30	ر Moon	د Merc.
12. الحوت Al-Hut Pisces	27. ماء خر Mā'khurr	ی 10	ل Sat.	ه Venus
		ك 20	ی Jup.	س Sun
	28. رشا Rishā	ل 30	ح Mars	ح Mars

Just outside the 7th margin, on either side of the vertical diameter is recorded the name of the *maker* and the *year* in the words— صنعه محمد زمان المنجم الاسطرلابی سنه فی غع meaning "Work of Mahamad Zamān the astronomer, the astrolabe-maker, in the year 1070"

Attached to the horizontal diameter is a rectangular table 57 x 28½ Mm. which is divided into equal halves by the vertical diameter. The outer edge of this table is used as a shadow-graph. Under the left small side are written the words ẓill-i-aqdām ma'kūs (ظل اقدام معکوس) "reversed shadows in feet"; this side is divided into seven parts marked respectively ا, ب, ح, ی, ه, و, ز *i. e.* 1, 2, 3, 4, 5, 6, and 7 corresponding respectively to altitudes 8°, 16°, 23°, 30°, 35°, 40°, 45°. These are the vertical shadows of a horizontal gnomon 7 feet in length held in the plane of the sun.

Then in the other half of the quadrant C under the left half of the longer side of the rectangle are the words ẓill-i-aqdām mustavi (ظل اقدام مستوی) 'direct shadows in feet", but by some mistake the letters have been *reversed* in engraving. The margin of the rectangle is divided as before into 7 parts marked respectively from the left ز (7), و (6), ه (5), ی (4), ح (3), ب (2), ا (1) corresponding to altitudes 45°, 49°½, 54°½, 60°, 67°, 74°, 82°.

The remaining half of the longer side of the rectangle (falling in quadrant D) is divided into 12 parts with ẓill-i-aṣābi'a mustawi (ظل اصابع مستوی) "direct shadows in fingers"; each group of 3 parts is marked respectively ح, و, ط, یب *i. e.* ج و, ط, یب, *i. e.* 3, 6, 9, 12 and corresponds to altitudes 76°, 63°½, 53°, 45°.

The right smaller side of the rectangle bears under it the words ẓill-i-aṣbi'a ma'kūs (ظل اصابع معکوس) "reverse shadows in fingers" and is divided into 12 parts, each group of 3 parts being numbered ب (12), ط (9), و (6), and ح (3) corresponding to the altitudes 45°, 37°, 26½° and 14°.

[The terms ظل مستوی (ẓill-i-mustawi) and ظل معکوس (ẓill-i-ma'kus) are already explained above (p. 9) and their complementary characters could be easily noticed as the direct shadow at an altitude of 67° is 3 aqdām, the reverse shadow at 23° is also 3 aqdām; the angles 67° and 23°, being complementary and so on.

Mr. Kaye, A. O. J. S., pp. 22, 29, fig. 25, has shown how these shadow scales could be graduated: but the graduations are the same as in the first and the second semicircular margins, first from 0° to 45° from the bottom for direct shadows and then carrying on equal graduations from 45° to 90°, but in a reverse order for reverse shadows].

Further in the centre above the shadow scales there are rectangular tables, consisting really of two sets of Tables, containing altogether 9 columns: in the first column to the right are the names of the twelve zodiacal signs: columns 2 to 6 are headed جدولِ حدودِ مصریان [jadwal-i-ḥudūd-i-misryān = Tables of Ḥudud (Terms or limits) as in vogue amongst the Egyptians]: they give the Limits and the ruling planets or the Lords (خداوندان) ruling the Limits: the columns 7 to 9 are headed ارباب مثلثات یومی (arbāb-i-muthallathāt-i-yūmī = Lords of the Day Trigons): they give the day Trigons, under the various zodiacal signs and their Lords. The Tables of Limits and their Lords, as well as the day Trigons and their Lords are the same as in Kaye A.O J.S., p. 125, and Al-Bīrunī Tfhm. pp. 410, 411, 351, 352. (Persian Edit.)

These Tables are copied further on, but it may be of interest to know in the first instance what this Astrological Technical term "ḥudud" (Limits) means.

حدود Ḥudud (pl. of حد ḥad=limit) generally means "limits" or "terms", but for strictly technical interpretation, the following remarks of Al-Bīrunī, Tfhm p. 409, are self-explanatory:—

"Astrologers have apportioned each zodiacal sign into five parts and these parts are not necessarily all equal—some greater and some smaller-and this is known amongst the Persians as مرز (*marz* = limit): each *marz* is assigned to a particular planet (the Sun and the Moon excluded). But different schools of Astrologers are not unanimous on these limits. There are limits which are connected with the Khāldians, who were originally Babilonians. There are tables of Limits as adopted by اسطراطوس (Asṭorāṭūs). There are also tables of limits in use amongst the Hindus: but a good majority of men of Science seem more favourably inclined towards the Tables prepared by the Egyptians. That school of Astrologers who follow Ptolemy, make use of the Tables given by him, who is supposed to have discovered them in a very old book".

On this Astrolabe in question, the Egyptian Tables are preferred, and they are copied as under.

جدول حدود مصریان Jadwal-i-Ḥudūd-i-Mirsyān					بروج	Tables of "Ḥudud" (Terms or Limits) as prepared by the Egyptians				
ل ل	ح كه	د ك	ه يب	ے و	حمل Aries	Jupiter 6	Venus 12	Mercury 20	Mars 25	Saturn 30
ح ل	ل كز	ے كب	د يب	ه ح	ثور Taurus	Venus 8	Mercury 12	Jupiter 22	Saturn 27	Mars 30
ل ل	ح كد	ه يز	ے يب	د و	جوزا Gemini	Mercury 6	Jupiter 12	Venus 17	Mars 24	Saturn 30
ل ل	ے كو	د يط	ه يج	ح (A)و	سرطان Cancer	Mars 6(A)	Venus 13	Mercury 19	Jupiter 26	Saturn 30
ح ل	د كد	ل يح	ه يا	ے و	اسد Leo	Jupiter 6	Venus 11	Saturn 18	Mercury 24	Mars 30
ل ل	ح كح	ے كا	ه يز	د ز	سنبله' Virgo	Mercury 7	Venus 17	Jupiter 21	Mars 28	Saturn 30
ح ل	ه كح	ے كا	د يد	ل و	میزان Libra	Saturn 6	Mercury 14	Jupiter 21	Venus 28	Mars 30
ل ل	ے كد	د يط	ه يا	ح ز	عقرب Scorpio	Mars 7	Venus 11	Mercury 19	Jupiter 24	Saturn 30
ح ل	ل كو	د كا	ه يز	ے يب	قوس Sagittarius	Jupiter 12	Venus 17	Mercury 21	Saturn 26	Mars 30
ح ل	ل كو	ه كب	ے يد	د ز	جدی Capricorn	Mercury 7	Jupiter 14	Venus 22	Saturn 26	Mars 30
ل ل	ح كه	ے ك	ه يج	د ز	دلو Aquarius	Mercury 7	Venus 13	Jupiter 20	Mars 25	Saturn 30
ل	ل	يط	يو	ز(B)	حوت Pisces	Venus 7(B)	Jupiter 16	Mercury 19	Mars 28	Saturn 30

(A) MPK has corrected و into ز , and Al-Bīrūnī and Kaye also give ز = 7.

(B) MPK has corrcted ز intd يب, and Al-Bīrūnī and Kaye give يب = 12.

The second set of Tables given in the centre, in columns 7 to 9, are those of Day Trignons or Triplicities and their Lords (ارباب’ مثلثات یومی) arbāb-i-muthallthāt-i-yūmī.

" مثلثات’ (muthallathāt) (pl. of مثلث Trigon or triangle) mean those zodiacal signs in groups of three which are of a uniform character not only as regards their natures, but are also at the corners of the equilateral triangles they form in the heavens; and for this reason those zodiacal signs are to be considered as alike-ones. They remain friendly, and work harmoniously with one another.

The *first* مثلث’ (muthallath) is formed by (1) *Aries*, (5) *Leo* and (9) *Sagittarius*: they are *fiery* signs, and they are producers of Fire. *Aries* presides over that fire which is in household use, and is useful to mankind; *Leo* presides over that fire which is in minerals and trees, and *Sagittarius* presides over that natural fire which pervades universally in the bodies of living animals.

The *second* مثلث (muthallath) is formed by (2) *Taurus*, (6) *Virgo* and (10) *Capricorn* and is connected with dust or dusty elements, and are givers of opulence. *Taurus* presides over those grasses which have no seeds; *Virgo* over those trees which are produced from seeds but which are of a smaller size, whilst *Capricorn*, over tall, lofty and full grown trees.

The *third* مثلث’ (muthallath) is formed by (3) *Gemini*, (7) *Libra* and (11) *Aquarius*, and is connected with *air* and blowing *winds*; *Gemini* presides over bracing air which enlivens and keeps alive all living beings: *Libra*, over those winds and breezes by which trees grow, and produce abundance of fruits; whilst *Aquarius*, over injurious and destructive and hard-blowing winds.

The last مثلث (muthallath) is formed by (4) *Cancer*, (8) *Scorpio* and (12) Pisces, and they are watery signs: *Cancer*, over sweet and pure water; *Scorpio*, over mixed, hard, and water trickling with difficulty: and *Pisces*, over brackish, dirty and stinking water." Al-Bīrūni, Tfhm, pp. 351, 352. (Persian Edition)

On this Astrolabe, the Day Trigons only are tabulated, but there are Night Trigons also with their ruling Lords. Kaye A. O. J. S., pp. 23, 125. The Trigon or Triplicity in Hindu Astrology is known as "dreshkāna" or "trikāna". In addition to this, there are Tables of "Septenaries" occurring only on the "zarqāli instruments"; of "Novenaries", (Navāṁshas), نوهبهرها (noh-baharahā); of Duo-decanaries (Dvādshāmshas), اثنا عشريات (athnā-'asharyyāt); and "Tridecanaries" (Trishāmshas), in use in Astrology, but not given on this Astrolabe.

Although on the Astrolabe, there are given Day Trigons only and their Lords, in the following Tables, Night Trigons are also included, so as to make the Tables complete, as well as there is a column to indicate their nature, as explained by Al-Bīrūnī, p. 352 and Kaye, A. O. J. S., p. 125.]

[*see Tables on pp. 22—23*]

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THE FRONT OF THE ASTROLABE.

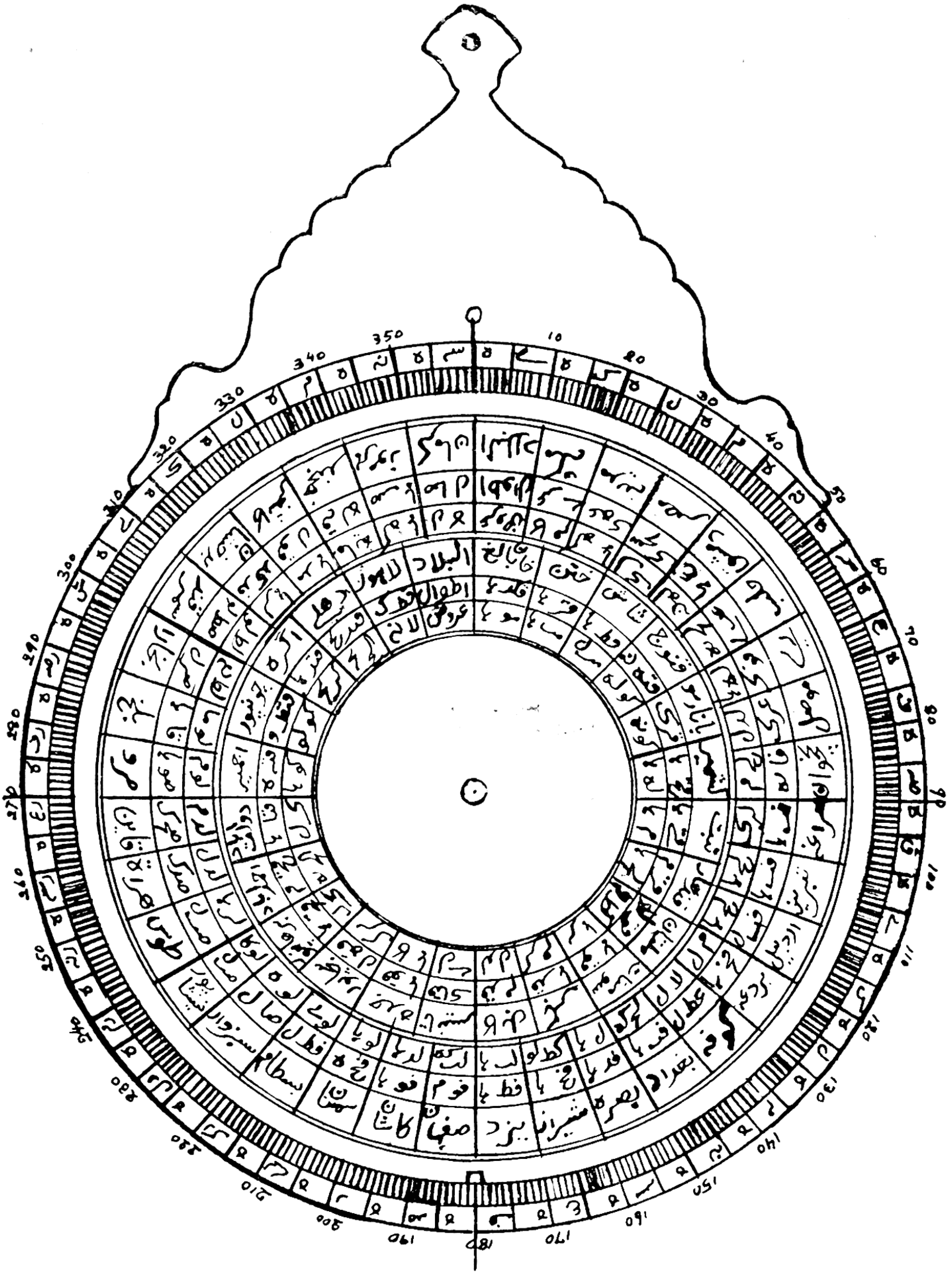

Fig. 3.—The Front of the JBP Astrolabe. (the discs being removed)

نهاد شان Their nature & Character	بروج Zodiacal Constellation	ارباب مثلثات یومی			ارباب مثلثات لیلی		
آتشی Fiery	1. حمل Aries	س	ے	ل	ے	س	ل
خاکي Earthy	2. ثور Taurus	ه	ر	ح	ر	ه	ح
هوائی Airy	3. جوزا Gemini	ل	د	ے	د	ل	ے
آبی Watery	4. سرطان Cancer	ه	ح	ر	ح	ه	ر
آتشی Fiery	5. اسد Leo	س	ے	ل	ے	س	ل
خاکي Earthy	6. سنبله Virgo	ه	ر	ح	ر	ه	ح
هوائی Airy	7. میزان Libra	ل	د	ے	د	ل	ے
آبی Watery	8. عقرب Scorpio	ه	ح	ر	ح	ه	ر
آتشی Fiery	9. قوس Sagittarius	س	ے	ل	ے	س	ل
خاکی Earthy	10. جدی Capricorn	ه	ر	ح	ر	ه	ح
هوائی Airy	11. دلو Aquarius	ل	د	ے	د	ل	ے
آبی Watery	12. حوت Pisces	ه	ح	ر	ح	ه	ر

Lords 'of Day' Trigons			Lords 'of Night' Trigons		
Sun	Jupiter	Saturn	Jupiter	Sun	Saturn
Venus	Moon	Mars	Moon	Venus	Mars
Saturn	Mercury	Jupiter	Mercury	Saturn	Jupiter
Venus	Mars	Moon	Mars	Venus	Moon
Sun	Jupiter	Saturn	Jupiter	Sun	Saturn
Venus	Moon	Mars	Moon	Venus	Mars
Saturn	Mercury	Jupiter	Mercury	Saturn	Jupiter
Venus	Mars	Moon	Mars	Venus	Moon
Sun	Jupiter	Saturn	Jupiter	Sun	Saturn
Venus	Moon	Mars	Moon	Venus	Mars
Saturn	Mercury	Jupiter	Mercury	Saturn	Jupiter
Venus	Mars	Moon	Mars	Venus	Moon

This completes the astronomical details as given at the Back of the Astrolabe.

THE FRONT OF THE ASTROLAE

See Fig. III.

The diameter of the whole plate on this side is 128 Mm. and of the venter 112½ Mm.

On the rim are given in two margins the 360 degrees of the circle from above in the direction of the hands of a watch; The outer margin contains groups of 5 being numbered
5 10 5 20 5 30 5 40 5 50 5 60 5 70 5 80 5 90 5 100
ه, ے, ه, ك, ه, ل, ه, م, ه, نه, ه, س, ه, ع, ه, ف, ه, صه, ه, ق
5 10 5 20 5 30 5 40 5 50 5 60 5 70 5 80 5 90 5 200
ه, ے, ه, ك, ه, ل, ه, م, ه, نه, ه, س, ه, ع, ه, ف, ه, صه, ه, ر
5 210 5 220 5 230 5 240 5 250 5 260 5 270 5 280 5 290 5 300
ه, رے, ه, رك, ه, رل, ه, رم, ه, رنه, ه, رسه ه, رع, ه, رف, ه, رصه ه, ش
5 10 5 20 5 30 5 40 5 50 5 60
ه, ے, ه, ك, ه, ل, ه, م, ه, نه, ه, سه;
and the inner margin is divided into degrees.

One finds in the *Venter* six concentric circles; the first gives the names of places (البلاد) al-bilad and the second and third respectively their longitudes (اطوال) (Itwal) and latitudes (عروض) aruḍ; similarly, the 4th gives the names of places and 5th and 6th their longitudes and latitudes. The first series begins at the top and reads outwards, the heading in the first circle being البلاد al-bilad (places), in the second اطوال itwal (longitudes) and third عروض aruḍ (latitudes). The second series also begins at top and has the same words at the beginning of each circle, but the names read inwards. The details are as per tables appended hereunder.

[A closer examination of these tables enables us to form an idea of knowledge of Geography of the Artist, and the accuracy of the longitudes and latitudes of the important places, known in those days, by comparing them with the values of these elements determined in modern times by delicate scientific instruments unknown in those days. "The difference in the values of latitudes", says Mr. Kaye (**A.O.J.S.** P. 25) "may be taken as some criterion of the accuracy of the determinations, but must be remembered that the precise localities of the observations (old and modern) are not known. "The *longitude* differences point to some place about 35 degrees west of Greenwich as the point of origin. The zero meridian therefore passed through the Isles of Azores. Hence in general, there should be a difference of 35°, between the Longitudes as given on the astrolabe and those with reference to Greenwich. In this matter the Muhammadans copied the Greeks, who fixed upon the "*Fortunate Isles*", possibly as the western end of the world. These "Fortunate Isles" or as some say "l'ile de fer" were originally imaginery islands where the souls of the good were made happy, but later the name became attached to the *Canary islands.* In the Âin-i-Akbarī we read : " the Greeks commence their reckoning from (خالدات) Khālidāt, which are six islands in the western Ocean, which in ancient times were inhabited, but now are inundated, etc.' "

It is to be noticed that of the 57 Towns given on this Astrolabe, 15 are towns in India 14 in Persia 7 in Eastern Turkesten, 5 in Afghanistan, 4 in Azarbaijān, 4 in Erāk, 3 in Arabia, 2 in Syria, 1 in Egypt, 1 in Tibet and 1 in China.

Some notes are added after the tables to supplement information as regards some of the towns and the co-ordinates.]

Table of Towns with their Longitudes & Latitudes as given on the Astrolabe and also their co-ordinates known at present

(Al-bilād) البلاد		Towns	Itwāl اطوال	Arud عروض	Longitude as on the Astrolabe	Latitude as on the Astrolabe	Longitude as calculated in modern times	Latitude as calculated in modern times	Remarks
OUTER CIRCLE.									
1	مكّه	Mecca	عز ی	کا م	77°-10'	21°-40'	40°-17' E	21°-30' N	
2	مدينه	Medina	عه ک	که ها	75°-20'	25°- 0'	40°- 0' E	24°-25' N	
3	مصر	Miṣr (Egypt)(A)	سج ک	ل ک	63°-20'	30°-20'	31°-13' E 29°-53' E	30°- 1' N 31°- 9' N	Cairo Alexandria
4	دمشق	Damascus	ع ها	له(B) نه	70°- 0'	35°-50'(B)	36°-20' E	33°-30' N	
5	حلب	Aleppo	عب ی	(C) لج یه	72°-10'	33°-15' (C)	37°-16' E	36°-14' N	
6	رے	Rae	فو ک	له ها	86°-20'	35°- 0'	51°-30' E	35°-30' N	
7	موصل	Mōsul	عز ک	لد ل	77°-20'	34°-30'	43°-10' E	36°-13' N	
8	نخچوان	Nakhchivan(D)	فا یه	لح م	81°-15'	38°-40'	45°-30' E	39°-15' N	
9	مراغه	Maraghah(E)	فب ها	لز ک	82°- 0'	37°-20'	46°-19 E	37°-16' N	
10	تبريز	Tebriz	فب ها	لح ها	82°- 0'	38°- 0'	46°-22 E	37°-59' N	
11	اردبيل	Ardebil	فب ل	لح ها	82°-30'	38°- 0'	48°-30 E	38°-12' N	
12	بردعه	Barda'ah(F)	فج ها	م ل	83°- 0'	40°-30'	47°-15' E	40°-25' N	
13	كوفه	Kūffah	عط ل	لا ل	79°-30'	31°-30'	44°-15' E	32°-30' N	(Approx.)
14	بغداد	Baghdād	فب ها	لج كه	82°- 0'	33°-25'	44°-30' E	33°-18' N	(Approx.)
15	بصره	Buṣrah	فد ها	ل ها	84°- 0'	30°- 0'	47°-50' E	30°-34' N	
16	شراز	Shiraz	فح ها	كط لو	88°- 0'	29°-36'	52°-36' E	29°-33' N	

17	يزد	Yezd	فط ها	ل ها	89°- 0'	32°- 0'	54°-17' E	31°-58' N	
18	اصفهان	Iṣfahān	فو م	لب كه	86°-40'	32°-25'	51°-36' E	32°-44' N	
19	کاشان	Kāshān	فو ها	لد ها	86°- 0'	34°- 0'	51°-22' N	33°-58' N	
20	سمنان	Samnān	فح ه	لو ها	88°- 5'	36°- 0'	53°-30' E	35°-30' N	
21	بسطام	Basṭam	فط ل	لو ی	89°-30'	36°-10'	55°- 0' E	36°-30' N	(Approx.)
22	سبزوار	Sabzwar	صا ل	لو ه	91°-30'	36°- 5'	57°-40' E	36°-20' N	,,
23	نسابور	Nisāpur	صب ل	لو كا	92°-30'	36°-21'	58°-44' E	36°-11' N	,,
24	طوس	Ṭus	صب ل	لد ها	92°-30'	37°- 0'	59°-15' E	36°-30' N	
25	هرات	Herāt	صد ک	لد ل	94°-20'	34°-30'	62°- 7' E	34°-21' N	(Approx.)
26	قاين	Qāin	صج ک	لد م	93°-20'	34°-40'	59°-10' E	33°-42' N	
27	مرو	Marv	صو ها	لو م	96°- 0'	36°-40'	61°-55' E	37°-30' N	(Approx.)
28	بلخ	Balkh	قا ها	لو ما	101°- 0'	36°-41'	67°- 5' E	36°-46' N	
29	بخارا	Bokhārā	صز ل	لط ن	97°-30'	39°-50'	64°-35' E	39°-45' N	
30	سمرقند	Samarqand	صط لو	لط لو	99°-36'	39°-36'	66°-55' E	39°-40' N	
31	بدخشان	Badakshān(G)	قد كد	لز ها	104°-24'	37°- 0'	70°-40' E	37°-10' N	
32	کاشغر	Kāshghar	قو ل	(H) مد ها	106°-30'	44°- 0' (H)	76°- 0' E	39°-30' N	(Approx.)
33	خجند	Khojand	(Y) قه له	ما يه	100°-35'	41°-15'	69°-35' E	40-°15' N	
34	هرموز	Hormūz(I)	صب ها	كه ها	92°- 0'	25°- 0'	56°-30' E	26°-30' N	Hormuz Is.
							55°- 0' E	27°-30' N	(Approx.) Town
35	کرمان	Kermān	صا ل	ل ه	91°-30'	30°- 5'	57°- 0' E	30°-17' N	
INNER CIRCLE									
36	لاهور	Lāhore	قط ک	لا ن	109°-20'	31°-50'	74°-22' E	31°-31' N	
37	دهلی	Delhi	قد يج	كح يج	104°-13'	28°-13'	77°-18' E	28°-35' N	

(Al-bilād) البلاد		Towns	Itwāl اطوال	Arud عروض	Longitude as on the Astrolabe	Latitude as on the Astrolabe	Longitude as calculated in modern times	Latitude as calculated in modern times	Remarks
38	آگره	Agrā	قد ها	کز يج	104°- 0'	27°-13'	78°- 5' E	27°- 7' N	
39	جونپور	Jaunpur	قط و	کو لو	109°- 6'	26°-36'	82°-46' E	25°-46' N	
40	اجمير	Ajmere	قه ه	کو ها	105°- 5'	26°- 0'	74°-40' E	26°-22' N	
41	دولت آباد	Daulatābād	قيا ها	ک ل	111°- 0'	20°-30'	75°-15' E	19°-28' N	
42	احمد آباد	Ahmedābād	قح م	کج يه	108°-40'	23°-15'	72°-38' E	23°- 3' N	
43	برهانپور	Barhānpur	قح (J) ها	ک ل	108°- 0'	20°-30'	76°-20' E	21°-20' N	
44	بيجاپور	Bijāpur	قه ل	ز ک	105°-30'(K)	17°-20'	75°-50' E	16°-53' N	
45	جده	Jeddah	قو (L) ها	کا ها	106°- 0 (L)	21°- 0'	39°-17' E	21°-38' N	
46	تانيسر	Thānesar(M)	قيا ک	ل ی	111°-20'	30°-10'	76°-50' E	29°-59' N	
47	کابل	Kabul	قد م	لد ل	104°-40'	34°-30'	69°-10' E	34°-33' N	
48	بکّر	Bakkar	قد ها	کز م	104°- 0'	27°-40'	68°-30' E	28°- 0' N	(Approx.)
49	سومنات	Somnāth	قو ها	(N) ز ها	106°- 0'	17°- 0' N	70°-28' E	20°-53 N	
50	قندهار	Qandhār	قز (P) م	لج ها	107°-40' P	33°- 0'	65°-47' E	31°-42'	
51	تبت	Tibet(Q)	قی ها	م ها	110°- 0'	40°- 0'	91°-10' E	29°-50'	(Lhāssā)
52	کشمير	Kāshmir	قح ها	له ها	108°- 0'	35°- 0'	74°-50' E	34°-12'	(Srinagar)
53	باناارسو	Bānārasu (R)	قز ک	کو نه	107°-20'	26°-55'	82°- 2' E	25°-18' N	
54	قنوج	Qanauj (S)	قيه نه	کو له	115°-50'	26°-35'	79°-56' E	27°- 3' N	
55	شاس	Shās (T)	قط ها	مب ل	109°- 0'	42°-30'	69°-15' E	41°-30' N	(Tāshkand)
56	ختن	Khotan	قز (V) ها	مب ها	107°- 0'	42°- 0'(V)	79°-55' E	37°- 0' N	(Cathay)
57	خان بالغ	Khān Bāligh(W)	قکد ها	مو ها	124°- 0'	46°- 0'	116°-30' E	39°-55' N	(Peking)

NOTES

[A. By Egypt, what town of Egypt is meant is not known: hence coordinates of both Cairo and Alexandria are given for comparison.

B, C. It seems that the engraver whilst going through his work, interchanged 33 and 35, and has put down the wrong numbers 35 and 33.

D. A town in Russian Azarbaizan on the River Arraxes.

E. A town well-known for its well-organized observatory in old days. (*vide* Notes from Encyclopœdia of Islam printed hereafter)

F. An ancient town of historical importance in Transcausasia.

G. The co-ordinates of Faizābād, chief town of Badakhshān are put down here for comparison.

H. The latitude of Kāshgar is far in excess.

I. The town of Hormuz near the strait of Hormuz in the Persian Gulf.

J. ند corrected into نح: but even with this correction the longitude is nearly 3°½ too small.

K. Longitude too small by 5°½.

L. If it is really قو then the longitude of Jeddah and this differ miles apart, but if it is taken as عو wrongly engraved as قو i.e. 76 then only we come nearer to Jeddah: or it may be presumed that it is some city in India, and not Jeddah of Arabia: but عو in place of قو seems more reasonable.

M. This is the ancient historic town of Thāneshwar now not prosperous, about a short distance from Kurukshetra. Its original name is Sthāneshwar, i. e. Sthāna of Ishwar, and it is one of the oldest and most famous towns in India connected with the legends of the Mahābhārata and the exploits of the Pāṇḍava brethren. According to Al-Bīrūnī, Tfhm. pp. 199, the zero meridian of the Hindus which passes from the island of Lankā to Mount Merū, also passes through Ujjein, Rohitaka, Tānisar, and Yaman; and it is also situated on the boundary of the 3rd country (out of the seven countries into which the Iranians divided the then-known world).

N. The latitude of Sonmāth is marked very low, putting this city in the South. May it not be a mistake of the engraver making كد into كر and that into بر ? كد agrees very well.

P. If this is really Qandhār of Afghānistān, the given longitude places it far more to the East of present Qandhār (Kandhār).

Q. What town of Tibet is meant is not clear here. The given coordinates place it right upto 5° North of Srinagar, i. e. more than 300 miles.

R. قر is wrongly engraved for قیز which gives the longitude 117°. The modern name Benāres, is a variant of Vārānasi, Benārasi or Bānārasu as given here.

S. Qanauj is also an ancient city marking the boundary of the 2nd country (along with Benares and Kāmrupa) of the Iranians (vide Note M)

T. شاس or شاش (shās) is Arabicized form of Persian چاچ (chāch) and represents the ruins now called as old Tāshkand where the site of the city called Shāsh by Arabs and Chāch by Persians existed.

U. The longitude of Khotan is قیز and not قر (vide Note R).

V. The latitude and longitude of ختن (Khotan) differ widely—the latitude by 5° and longitude by 8°. Perhaps these places being beyond the Himalayas, its coordinates, could not have been accurately measured. In old days Khotan and Cathay were equivalents.

W. Khān Bāligh is "Cambalauk" which is a corruption of Khān Bāliq, or 'City of the Khān' (i.e. Kublā Khān), the Mongol name for Peking or Peiping as it is now called. It was so named by the famous traveller Marco Polo, when he paid a visit to Emperor Kublā Khān of China. Corvins writes it 'Cambaliech': he was appointed Arab bishop of the place in about 1305 by Kublā Khān, the great Khākān. Benedict Goez identified this place with Pekin in the seventeeth century. In Catalan Map of Asia of 1315, it is written "Chanbaleth" (Mogni Canis de Catayo). The coordinates of Peking are lat. 39° 55, N, long. 116°-30' E, quite different from those of Khān Bālegh as given on this Astrolabe: but a glance at the map of the world as given in Ptolemy's Geographia, and given by Sir Perey Sykes in his "The Quest for Cathay", will considerably allay the doubts about the knowledge of Geography of those days.

Y. The longitude قـه ought to be قد as in Mulla Feeroze Astrolabe, thereby giving a longitude closely agreeing with the modern value of the longitude.]

NOTES

[Attention may be drawn at this stage to the figures 4, 5, 6, 7, and 8 specially drawn for understanding the Tablets generally given with Astrolabes.

Fig. 4 represents the First Face of Tablet (I) described hereunder, giving the horizons at different latitudes. But in order that the figure may not appear unnecessarilly confusing by too many lines, only 32 Horizons at intervals of 2° each from 12° to 74° drawn in this figure. The first face of the Tablet I of the Astrolabe gives 63 horizons at intervals of 1° each, from 4° to 66°. The MFL Astrolabe gives only 27 horizon's from 14° to 66° at intervals of 2° each, and the lines extend to two quadrants only, whilst the JBP Astrolabe gives the horizons for all the four quadrants except for a small gap in the fourth quadrants, and hence that disc appears more crowded than the MFL disc which is neat and ornamental in appearance, as can be seen by comparing the two figures *4* and *13*.

The Tablet I (b) entitled "Safiḥah Mizān-i-'Ankabūt (صفیحه مزان عنکبوت = Tablet for measures on the 'Ankabut) is in fact a Tablet of Altitudes and Azimuths for a place of latitude (90°-w) i. e. 90°-$23^\circ\frac{1}{2}$ i.e. $66^\circ\frac{1}{2}$ (w being the obliquity of the Ecliptic). Similarity of this tablet with Tablets II, III, IV of this Astrolabe can be easily noticed. See figs. *5,7, 8*. With the help of this Tablet I (b), and fig. *5A & B*, the Longitudes and Latitudes of all the stars marked on the 'Ankabūt can be easily read out. But modern Astronomy pays equal importance to an another set of co-ordinates for fixing up the positions of the Heavenly Bodies viz., Right Ascension and Declination, measured along the Celestial Equator and along circles at right angles to the Equator, which all pass through the poles. In order to determine the Right Ascension and the Declination of the stars on the 'Ankabut, a simpler form of tablet as shown in fig. 6 is required which really has a series of concentric circles of gradually increasing radii from the pole (*i. e.* the centre) outwards. With the help of two such Tablets drawn to scale for JBP and MFL Astrolabes, the Right Ascensions and the Declinations of the stars on the 'Ankabūts of both these Artrolabes have been tabulated in the lists given hereunder. Further the MFL Astrolabe has not got the Tablet for the Measures on the ‘Ankabūt, and hence a Tablet similar to fig. 5 had to be prepared for the MFL Astrolabe to measure the Longitudes and Latitudes of the stars on its ‘Ankabūt. The Tablets of the MFL Astrolabe are about 116 mm. in diameter, whilst those of the JNP Astrolabe are 111 mm. in diameter, and hence owing to even such a small difference in diameters two sets of figures had to be drawn.]

TABLETS. (صفایح)

There are four brass tablets (صفایح) (Ṣafāih), each of 112 Mm. in diameter, and each with a rectangular notch fitting into a projection (called ممسکه' mumsikah) from inside the rim just over the venter, so that they remain fixed when placed on the venter.

Tablet I (a) has on one surface the horizons آفاق (āfāq, pl. of افق' ufq) it being the *Ṣafīḥah Al-Afāqiyah,* (Tablet of Horizons) although this name is not inscribed on it. It is similar to that of Kaye's instrument C of Herat, (Kaye, A. O. J. S., Fig. 15, and D. M. A. I. Fig. 22), but fuller, each horizon being not confined only to two quadrants as in those instruments, but extending to all the four quadrants, being only interrupted partly in the third. (vide Fig. 4).

Horizons are here given for every degree of latitude from 4° to 66° and a greater length of each horizon is given. Thus the horizons, for latitudes 6°, 10°, 14° and so on upto 66°, begin in the left upper quadrant, are carried through to the vertical line in the left lower quadrant, are interrupted in the right lower quadrant by the horizons for latitudes 5° to 65°, but are again taken up and carried through to the right upper quadrant. The horizons for latitudes 5°, 9°, 13° and so on upto 65° begin in the left lower quadrant are carried through the right lower quadrant interrupted partly in the right upper quadrant, but picked up and carried through to left upper quadrant. Similarly, the horizons for latitudes 7°, 11°, 15°, upto 63° begin in the right lower quadrant, are after interruption in the left upper quadrant carried through to the left lower quadrant; and then for latitudes 4°, 8°, 12°, upto 64°, begin in the right upper quadrant and are carried through to the right lower quadrants. The latitudes for each horizon is marked under it near the circumference both where it begins and where it ends

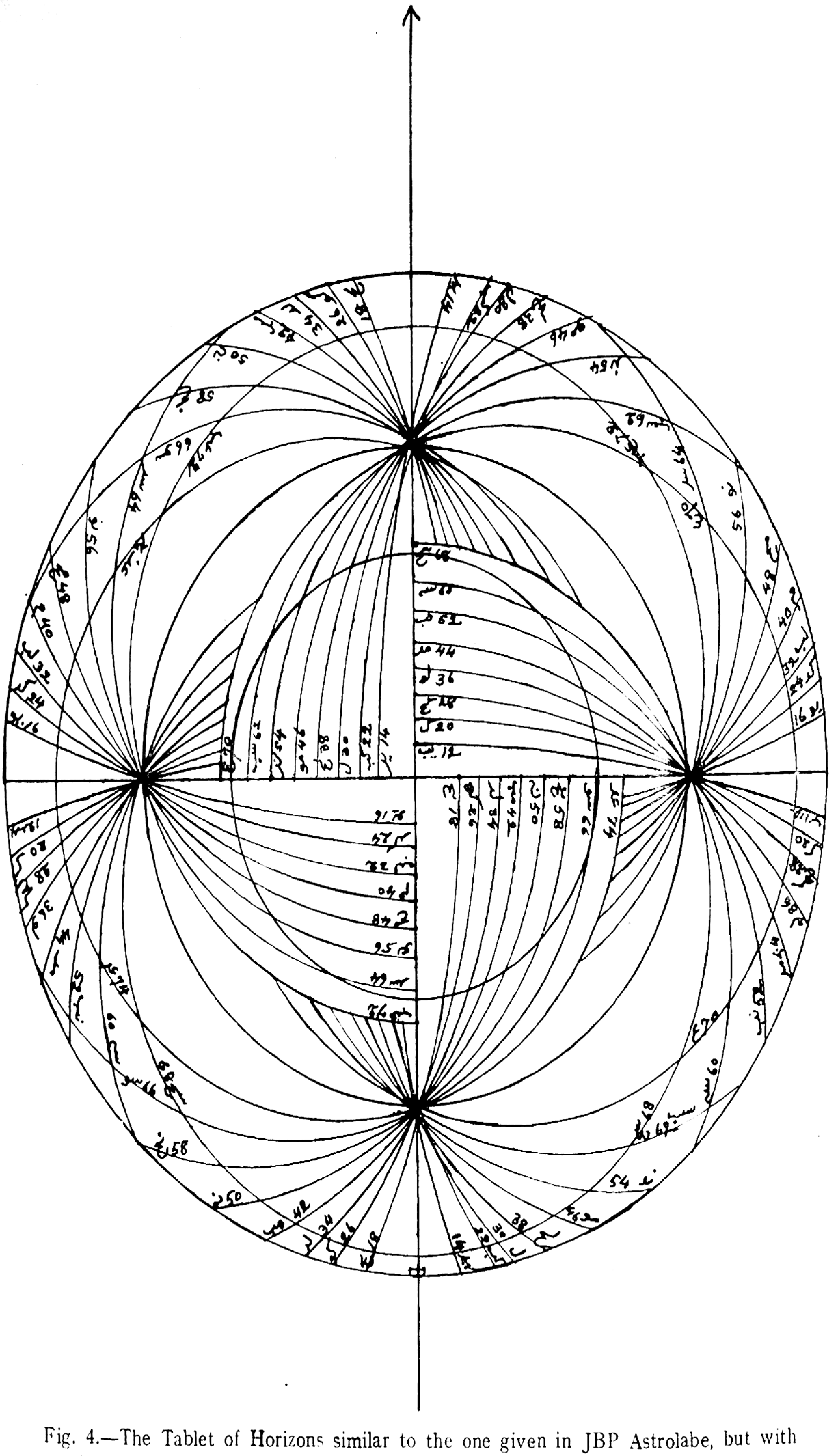

Fig. 4.—The Tablet of Horizons similar to the one given in JBP Astrolabe, but with intervals of 2° (to avoid crowding) and extending from 12° to 74° of Latitudes.

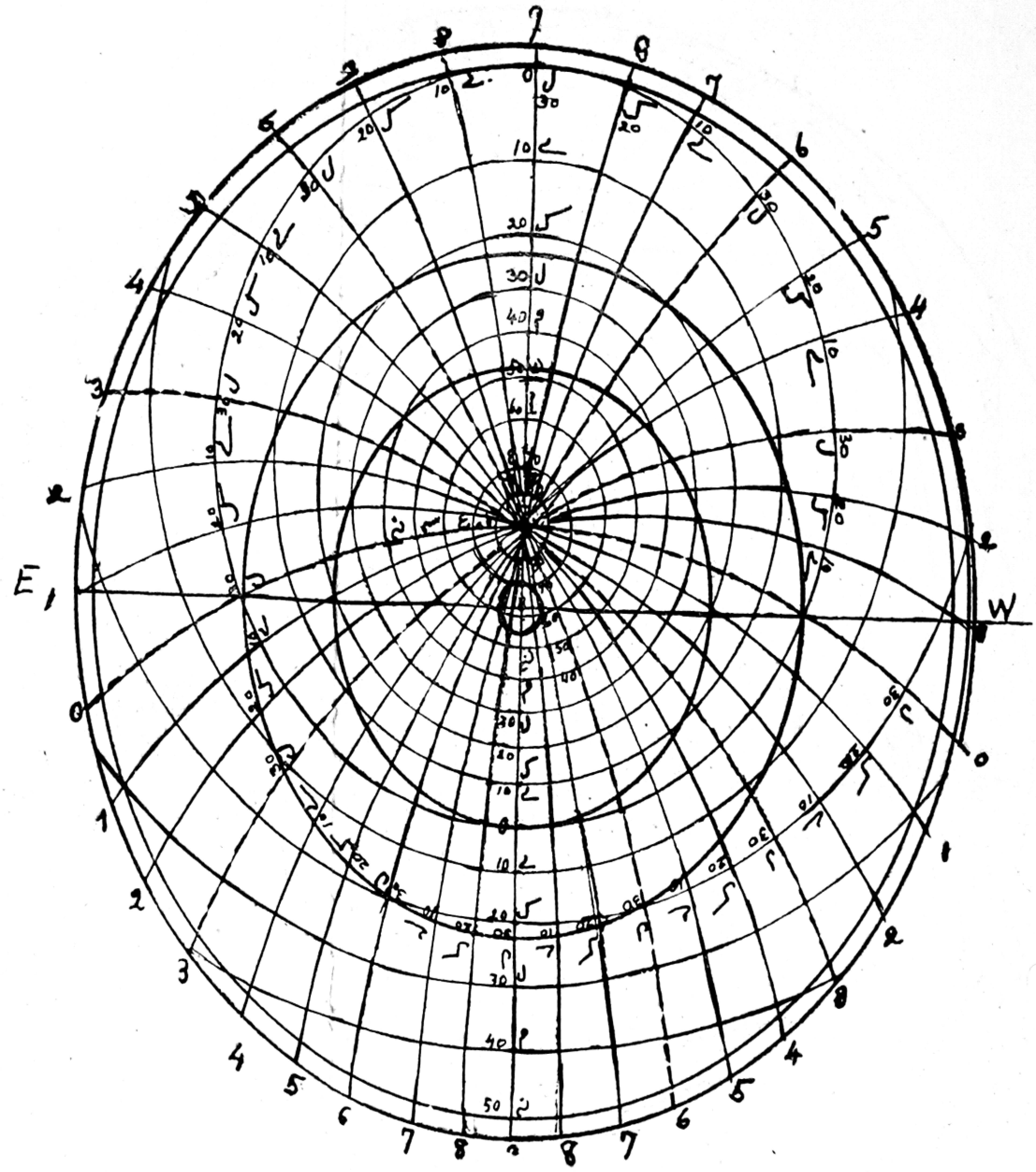

Fig. 5A.—The Tablet for Measures on the 'Ankabūt' (JBP Astrolabe) i. e. for the determination of Longitude and Latitude (at intervals of 10° of Latitude.)

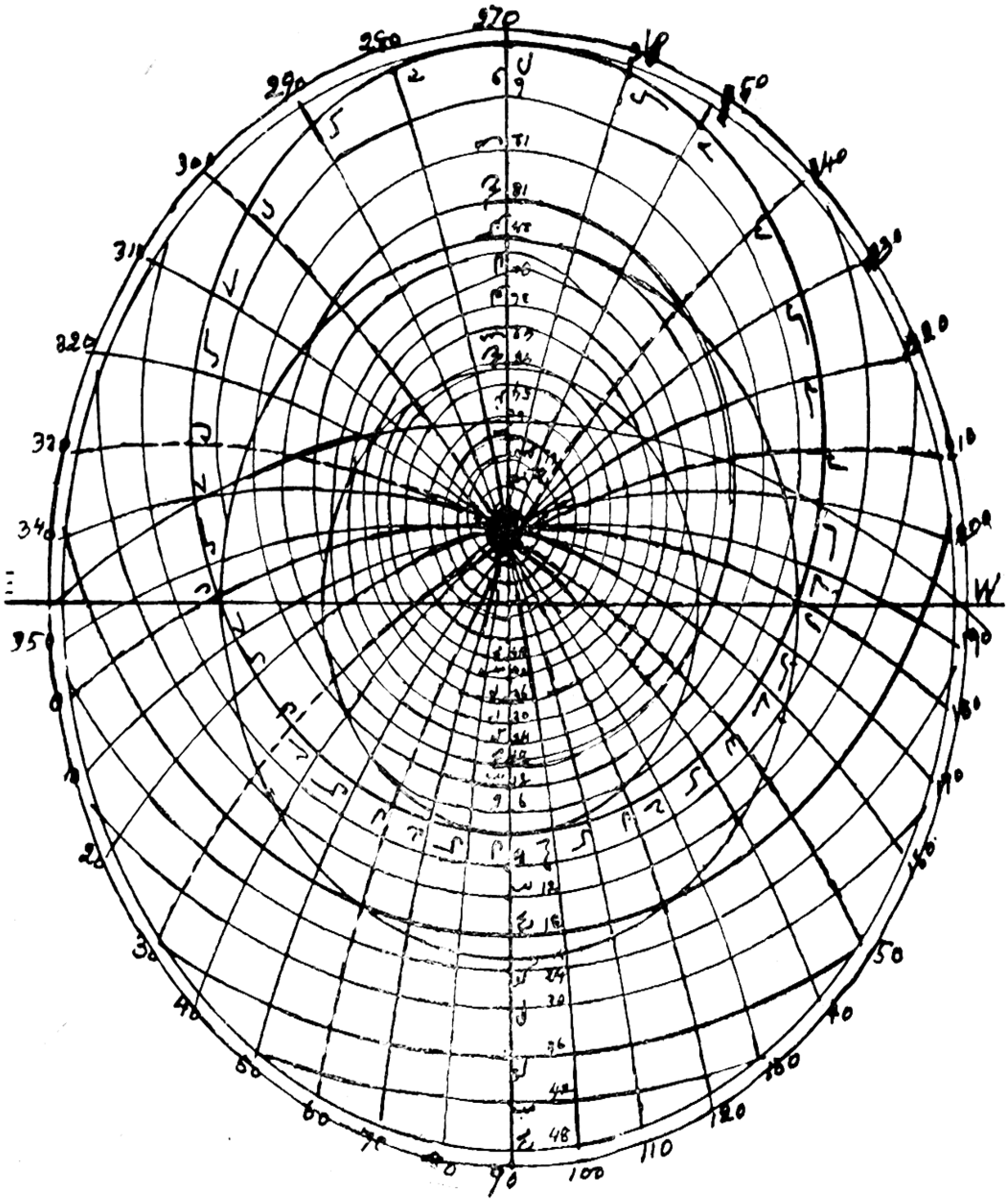

Fig. 5B.—The same as Fig. 5A—at intervals of 6° of Latitude, and it also represents the Tablet of Altitude and Azimuth at a place of Latitude 66½° N.

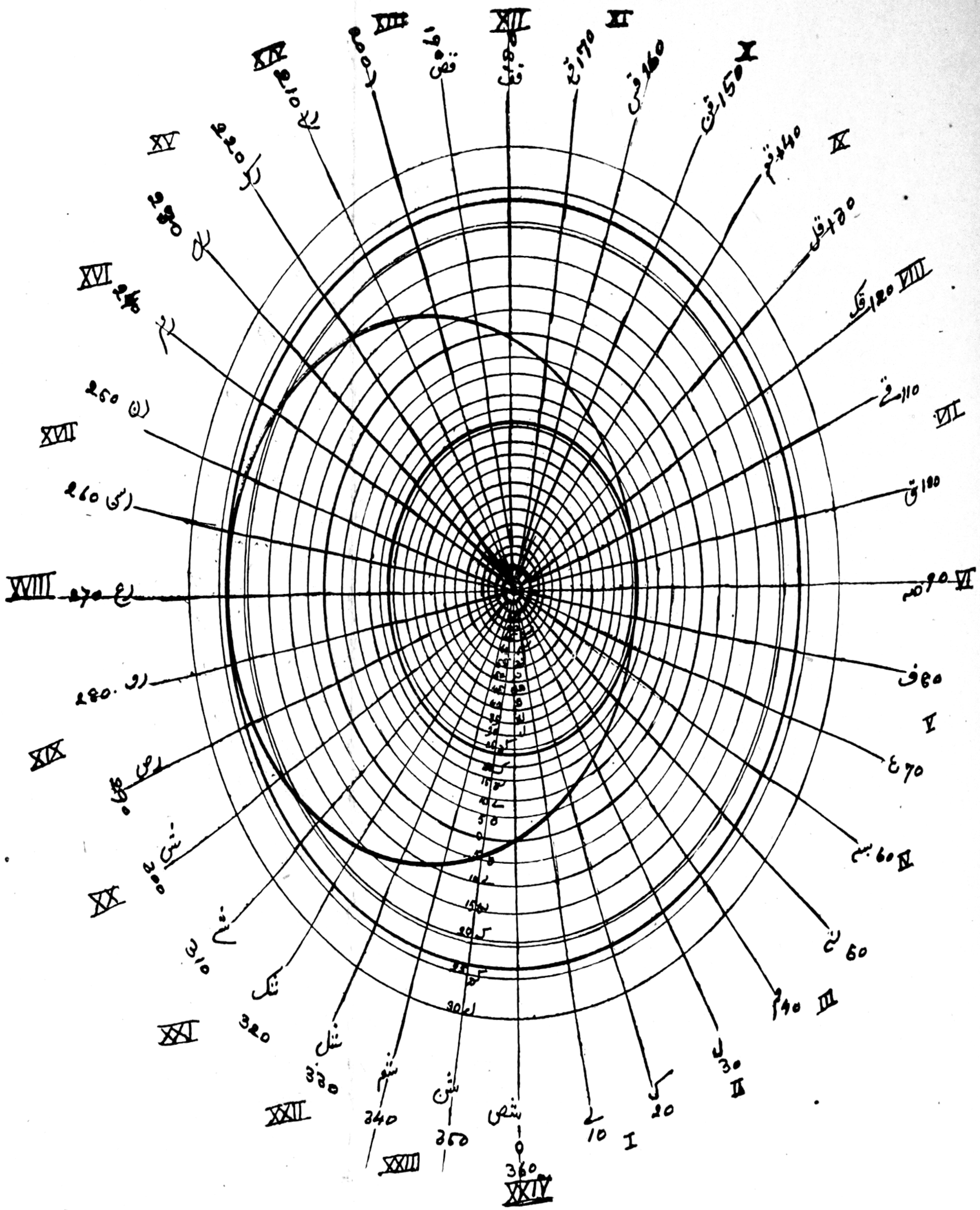

Fig. 6.—The Tablet for the determination of Right Ascension and Declination of Stars on the 'Ankabūt.'
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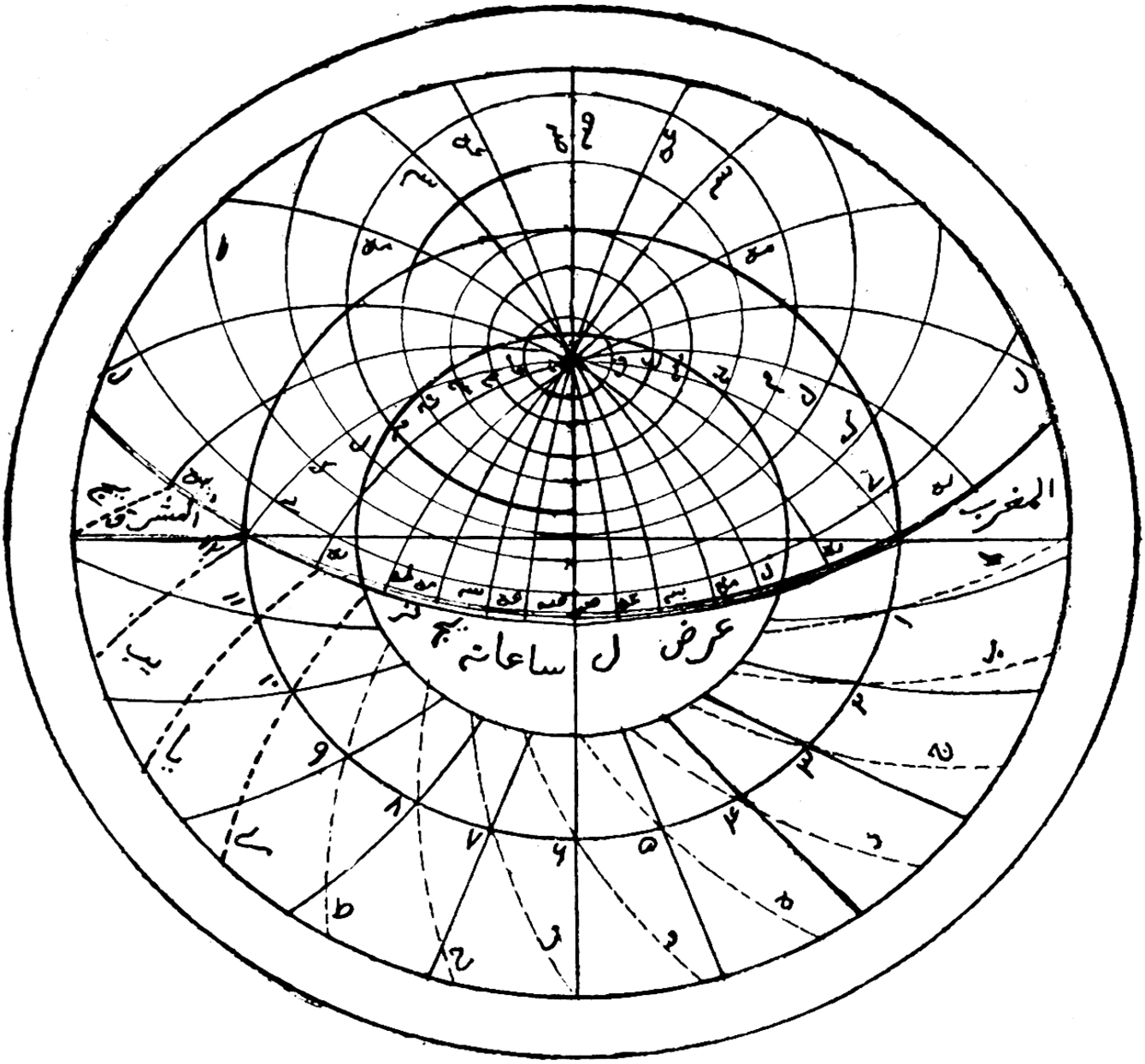
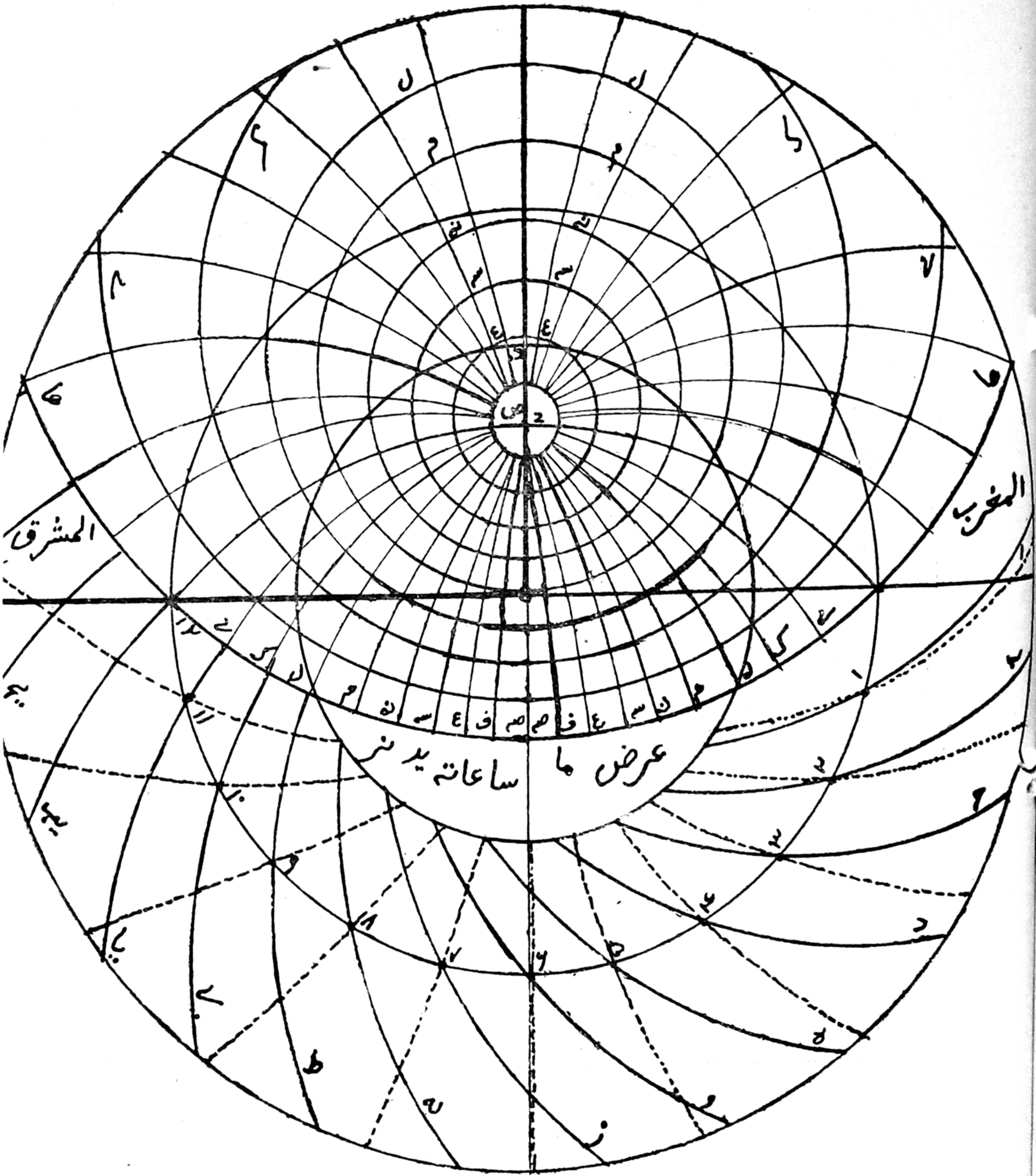


Fig. 7.—The Tablet for Almuqantarāts (Altitudes) and Summūt (Azimuths) at a place Latitude 30° N.



ig. 8.—The Tablet for Almuqantarāts (Altitudes) and Summūt (Azimuths) at a place Lat. 41° N.

and also above it close to the diameter which it cuts. The diameter of the *Tropic of Cancer* is 45 Mm., the *Equator*- 70 Mm., and the *Tropic of Capricorn*-108 Mm. (Kaye, A. O. J. S., P. 20 "Horizons" and Fig. 15; Kaye's D. M. A. I., P. 9 Table VI b and Fig. 22).

Tablet I (b) is marked *Ṣafiḥah Mizān Al 'Ankabūt* صفحه ميزان العنكبوت (Tablet for Measures on the 'Ankabut). It bears in addition to projection of the equator and the two tropics and the ecliptic, the circles of latitude for every 3°, from 90° N. to 40° S. and circles of longitude for every 10°. (Kaye-A.O. J. S. p. 20, "Ankabūt co-ordinates" and Kaye's Delhi Instruments, p. 8, Tablet VI (a) and Fig. 21). The diameter of the *equator*, the *two tropics* and the *ecliptic* are respectively 70, 45, 108 and 76.5 Mm. The ecliptic and the circles of longitude at the beginning of each Zodiacal sign Aries, Taurus etc. are shown in dotted lines. This Tablet easily enables one to determine the longitudes and the latitudes of all the stars marked upon the 'Ankabūt. In fact it is the tablet of the Latitude of the complement of total obliquity *i. e.* 90-23½° or 66½° similar to those described hereunder. *(vide Fig. 5A & B.)*

The other Tablets II to IV are marked on each side with stereographic projections of the *horizon* (افق ufq), the *Tropic of Cancer* (مدار سرطان madār-i-sarṭān), the *Tropic of Capricorn* (مدار جدى madār-i-jaddi), the Equator (مدار حمل و ميزان madār-i-ḥamal-u-mizān) in general; and parallels of *altitudes* (المقنطرات almuqanṭarāts), *azimuths* (سموت summūt, pl. of سمت samt), and *hour circles* (دايره ساعات dāirah-i-sā'āt) for a particular latitude (عرض arḍ) and longitude (طول ṭul) and also the duration of the longest day (ساعاته sā'ātah) for that latitude. If the muqanṭarāts (circles of altitude) are drawn on the tablet for every degree of altitude such an astrolabe is called (تم tamm or تمام tamām) complete or full. A تم (tamm) has therefore 90 circles of altitude. If, however, muqanṭarāts are marked for every 2° of altitude, i.e. 45 muqanṭarats, then such an astrolabe is called نصفى nisfi (lit. half-one), as it is a half of the full-one. If muqanṭarāts are drawn for every 3° of altitude, i. e. 30 muqanṭrāts from the horizon to the zenith, the astrolabe is called ثلثى (thulthi): if for every six degrees, it is called سدسى (sudsi) *(Fig. 5B)* and if for every 10°, it is called عشرى ('ashri). *(Fig. 5A)* Thus there are تم (tamm), نصفى (nisfi),

ثلثی (thulthi), سدسی’ (sudsi), and عشری ('ashri) astrolabes, but not خمسی (khumsi) *i. e.* those with circles of 5° intervals, though they are so convenient and desirable.

The other Tablets or Discs (II, III, IV,) are marked on each side with stereographic projection of the horizon and almuqanṭarats, azimuth, and hour circles for a particular latitude and also the equater and the tropics; also the duration of the longest day (ساعاته sa'ātah) for that latitude.

Tablet II (a) is like Kaye D. M. A. I. Plate III a, Fig. 15. It is marked 'ard Makkah عرض مكه *i. e.* latitude of Mecca, Sa'atah (ساعاته) IJ—K, (يج ك) *i. e.* Hours 13–20. It exhibits the Equator, tropic of cancer and tropic of Capricorn, and the coordinates for the latitude of Mekka. The Almuqanṭarāt or altitude circles are drawn for every 3° and thus this Tablet is a Thulthi (ثلثی) one, although numbered for every 6°, and the azimuth circles are drawn and numbered for every 10°. It has below the horizon the words (المشرق) "Al Mashriq" (the East) on the left and (المغرب) "Al Maghrib" (the West) on the right; the 12 temporal hour lines numbered 1 to 6 from each side and the twelve equal hour lines in right quadrant are as shown in Kaye's figure, the hour being reckoned from the western horizon, but in the left quadrant they are drawn into, so that the hours have to be reckoned from the eastern horizon. The prime vertical, the altitude circles for 30°, 60°, 90° (*i. e.* the horizon) and the equal hour lines are all dotted.

Tablet II (*b*) is like Kaye D. M. A. I., Plate IV a, Fig. 17. It is marked (عرض مدينه) 'Arḍ Madinah–KH (كه) *i. e.* (Latitude of Madinah 25°), (ساعاته) Sā'ātah IJ–LD (يج لد) Hours 13–34. It exhibits the coordinates of Madinah, being in all other respects like *Tablet* II (a).

Tablet III (*a*) *(see Fig. 7)* is marked 'Arḍ L (ل) (Latitude 30°) Sā'ātah IJ-NZ (يج نز) *i.e.* (hours 13-57). It exhibits the coordinates for latitude 30° and is in most respects similar to Plate II (a), but the altitude circles are not numbered along the meridian, and the hour-lines are marked and numbered as in Kaye's D.M.A.I. Figures 13 to 20, they being numbered from 1 to 12 for the temporal hours from the western horizon and drawn and marked 1 to 13 for the equal hours from the same horizon.

The Almukanṭarāt or altitude circles are drawn for every 3° and so the *tablet* is a Thulthi (ثلثی) one; they are numbered for every 6° both along the meridian and prime vertical. The azimuth circles are drawn and numbered for every 10°, first along the horizon and then between the circles for altitudes 42° and 45° or close to the circle for altitude 45°.

Tablet III (b) is marked ‘Arḍ LB (لب) (Latitude 32°), Sā‘ātah ID -Z (يد ز) (Hours 14-7). It exhibits the coordinates for latitude 32° and is similar to *Tablet* II (a), except that the altitude circles are numbered along the meridian also and the 14th equal hour line is also shown.

Tablet IV (a) is marked ‘Arḍ LD (لد) (Latitude 34°), Sā‘ātah ID-IZ (يد ز) (*i.e.* Hours 14-17). It shows the coordinates for latitude 34° and is in other respects similar to *Tablet* II (a).

Tablet IV (b) is marked ‘Arḍ LZ (لز) (Latitude 37°) Sā‘atah ID-LD (يد لد *i. e.* Hours 14-34). It shows the coordinates for latitude 37° and is in other respects similar to *Tablet* II (a).

THE 'ANKABUT (عنكبوت)

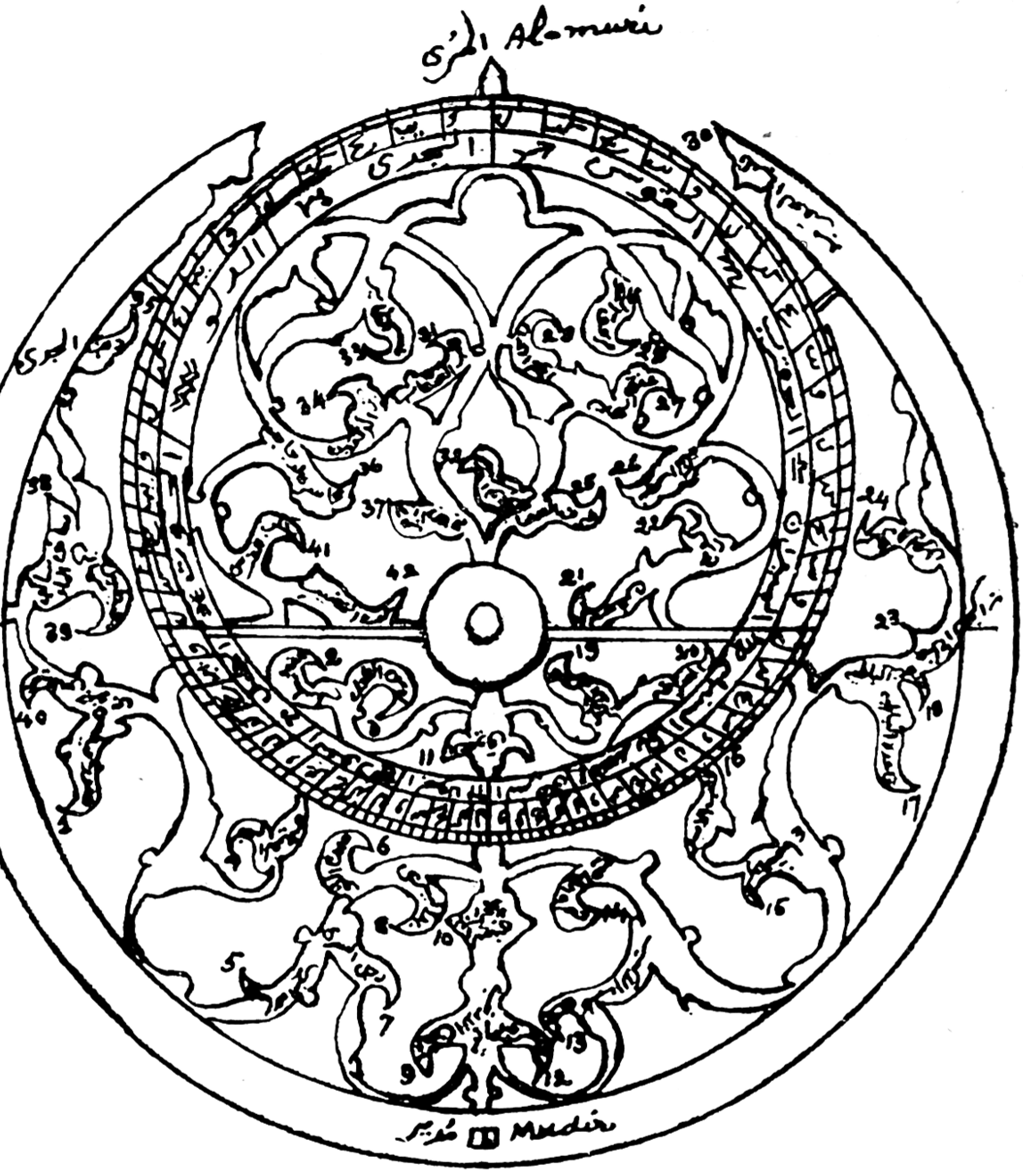


Fig. 9.—The 'Ankabūt of the JBP Astrolabe

The 'Ankabūt (عنكبوت) or spider or aranea or شبكة (shabakah) rete, net, has seven joints. It has usual ecliptic circle 76. 6 Mm. in diameter with a bevelled edge and flat rim; the inner part of the rim is divided into 12 parts each bearing the name of sign of the zodiac; and the outer part of the rim is divided into groups of 6° of longitude, there being 5 such groups for each sign, numbered 6, 12, 18, 24 and 30 (و , يب , يح , كد and ل); the bevelled edge is divided into groups of 3° of longitude, but the divisions are blurred at some places.

[It is an open work Tablet so arranged ornamentally that the tablet below it can be conveniently seen through. Names of 42 important bright stars for observation,–22 south of the Ecliptic and 20 North of the Ecliptic are marked on the ornamental projections terminating in fine points called (شظايا) shaẓāyā, (pl. of شظية shaẓyah = a splinter) or مريها (murihā) pointers—indicating the exact positions of the stars whose names are engraved on the branches. With the help of the Tablet "Ṣafiyah Mizān-i-'Ankabūt," *(Fig. 5 A & B)* placed under the 'Ankabūt, the longitudes and latitudes of these stars can be conveniently read out; and when compared with the longitudes of these stars at present, the year of manufacture of the instrument can be determined, as owing to precession of Equinoxes, the longitudes of stars annually increaee by 50.2″, whilst the latitudes remain unchanged. 'Ankabūt is capable of central rotation along the pivot (قطب Qūṭūb), and when used in conjunction with the other tablets can enable us, with the help of star catalogues and Almanacs to determine the hour of day or night from observed altitudes of the Sun or the stars and vice-versa. A complete list of the stars engraved on the 'Ankabūt with their longitudes and latitudes as read out with the help of the Ṣafiyah Mizān-i-'Ankabūt, and their probable equivalents according to Modern Astronomy are given hereunder in the Tables.

At the junction of the point at the beginning of the Sign (الجدى al-jaddi) (Capricornus) and the end of the Sign (القوس al-qaus = Sagittarius), there is an index or a pointer, called by the Arabs المرى (Al-Muri), and is so designed as to move freely over the outer graduated circle of the Astrolabe; and in order to facilitate such a rotation a vertical peg or projection is attached to the 'Ankabūt at the opposite end of the diameter passing through the principal index (المرى). It is called مدير (mudir) by the Arabs.

The 42 principal stars which are marked on this 'Ankabūt are given below with their Celestial longitudes and latitudes, as read out with the help of Ṣafiyaḥ-i-Mizān-i-'Ankabūt, *(Fig. 5A & B)* and their probable Right-Ascensions and Declinations, as read out with the help of a special tablet as per *(Fig 6)* placed underneath the 'Ankabūṭ' are also added in separate columns.]

Name of the Star			Longitude	Latitude	Probable Identification	Right Ascension	Declination
1	صد ر قيطس	Sadra Qitus [Breast of Cetus]	16°	26°½ S	Probably 5 L 7 Ceti [Kaye takes it as ε Ceti]	24°	17°½N
2	جنب امسله جنب مسلسله	Janb Amsala is perhaps Janab al-Musulsala i. e. Southern one of the chained (Andromoeda)	25°	27° N	43 β Andromedāē	12°½	33° N
3	راس الغول	Rās Al-Ghūl [Head of the Devil]	52°	27° N	26 β Persei, its co-ordinates are 48°-55' and 22° N, but the co-ordinates are those of 27 Persei, which are 50°-43' and 26° N. [Algol]	44°	42° N
4	فم القيطس	Fum al-Qitus [Mouth of Cetus]	40°	13°½ S	86 γ Ceti [Kaye takes it as α Ceti (Minkar)]	41°	3°½ N
5	مسافه النهر	Musāfah Al-Nahr [Valley or expanse of the river]	50°	33° S	34 γ Eridani	57°	14° S
6	عين الثور	'Ain Al-Thūr [Eye of the Bull]	63°	5° S	[α Tauri (Aldebarān)]	62°	17° N
7	رجل اليسرى	Rijl Al-Yasri [Left-sided foot] (of Orion)	70°	30° S	[β Orionis (Rigel)]	74°	8° S
8	يد اليسرى	Yad Al-yasri [Left sided hand] (of Orion)	76°	18° S	[γ Orionis (Bellatrix)]	77°	5° N
9	قطن الارنب	Qaṭan Al-Arnab Lepus 11, (See Hamal) [Lair of the Hare]	80°	39° S	[α Lupus]	82°	13° S
10	يد اليمنى الجوزا	Yad Al-yamani al-Jauzā [Right hand of Orion]	85°	16°½	[α Orionis (Betelgaux)]	85 °	7° N

11	العيوق	Al-'Ayūq [The driver or charioteer]	78°	21° N	[α Aurigæ (Capella)]	74°	45° N
12	شعری الیمانیه	Shi'ari Al-Yamānih [Shi'ari towards Yemen *i.e.* Southern]	101°	40° S	[α Canis Major (Sirius)]	98°	15° S
13	اذن کلب الاکبر	Uzn Kalb-ul-Akbar [Ear of the greater dog]	103°	34°½ S	[θ Canis Major]	100°	11° S
14	شعری الشامیه	Shi'ari Al-Shamih [Shi'ari towards Shām or Syria *i.e.* Northern]	114°	15° S	[α Canis Minor (Procyone); also called سگ مقدم (sag-i-mukkadam) Forward dog or ذراع مقبوصی (Dharrāh Maqbuṣa)]	113°	7° N
15	فرد الشجاع	Fard Al-Shuja' [Solitary one of the warriors.]	142°	22°½ S	[α Hydra (Alpherd)]	137°	6° S
16	قلب الاسد	Qalb Al-Asad [Heart of the Lion.]	146°	0°	[α Leonis (Regulus)]	147°	4° N
17	قاعده الباطیه	Qa'idah Al-Bāṭih [The bottom of the Cup]	169°	24° S	[α Crater]	160°	18° S
18	سفه الباطیه	Safaha Al-Bāṭih [The deeper side of the cup.]	178°	19° S	[γ or δ Crater]	171°	17° S
19	(ظهر) دب الاکبر	(Zahr) Dubb Al-Akbar [The Back of the greater Bear]	130°	52° N	[α Ursa Majoris]	160°	65° N
20	الصرفه	Al-Surfah [Hind part of the Lion]	170°	18° N	[β Leonis (Denebola)]	178°	21° N
21	الحفن	Al-Ḥafan [The double one]	160°	55° N	Probably 79 ζ Ursa Majoris	194°	58° N

Name of the Star			Longitude	Latitude	Probable Identification.	Right Ascension	Declination
22	السماك الرامح	Al-Simāk Al-Ramiḥ [The Simāk with the spear]	198°	34° N	[α Bootes (Arcturus)]	210°	23°½ N
23	جناح الغراب	Janāḥ Al-Ghurrāb [Wings of the Crow]	187°	14 S	4 γ Corvi	180°	15° S
24	سماك الاعزل	Simāk Al-A‘zal [The Simāk, unarmed]	197°	2 S	[α Virginis (Spica)]	196°	6° S
25	طرف العصا	Tarf Al-Asā [head or extremity of staff]	208°	52° N	51 μ Bootes.	227°	38° N
26	نيّر الفكه	Naiyir Al-Fakka [The Bright one of the Bowl]	217°	45° N	5 α Corona Borealis	230°	29° N
27	عنق الحيّه	‘Unq Al-Haiya [The neck of the serpent]	227°	25° N	27 λ Serpentis or α Serpentis	231°	8° N
28	مرفق الحوّا	Mirfaq Al-Ḥawwā [The elbow of the serpent charmer]	241°	24° N	10 λ Ophiuci	243°	5° N
29	راس الحوّا	Rās Al-Ḥawwā [The head of snake charmer]	257°	31° N	55 α Ophiuci (but the latitude should be about 36°)	258°	8° N
30	قلب العقرب	Qalb Al-‘aqrab [Heart of the scorpion.]	244° or 246°	1°½ S 4°½ S	21 α Scorpii (the second set of co-ordinates is nearer to Kayes.)	243°	25° S
31	ذنب العقاب	Ẓanab Al-‘Uqāb [Tail of Aquilla, Eagle]	286°	36° N	17 ζ Aquillœ	282°	11° N
32	نسرالواقع	Nasr Al-wāqi‘a [SwoopingEagle]	283°	61° N	3 α Lyræ [Vega]	276°	40° N

33	نسر الطاير	Nasr Al-Ṭāir [Soaring Eagle]	299°	30° N	53 α Aquillæ [Altair]	293°	8° N
34	ذنب الدلفين	Zanab Al-Dalfīn [Tail of Dolphin]	310°	32°½ N	9 α or 6 β Delphini.	303°	12°½ N
35	ذنب الجدی	Zanab Al-Jaddi [Tail of the Goat]	317°	3° S	40 γ Capricorni	320°	18°½ S
36	عاسرة الدجاجه	'Assirat Al-Dajāja [Feathers of the Hen]	328°	13°½ N	46 ζ Cygni.	312°	27° N
37	ذنب الدجاجه	Zanab Al-Dajāja [Tail of the Hen]	330°	59° N	50 α Cygni	308°	42° N
38	ساق ساکب الماء	Sāq Sākib Al-Mā' [Leg of the Water-bearer]	342°	9° S	76 δ Aquarii; Kaye gives it as 335 or 332 ξ Aquarii	346°	16° S
39	شمالي قيطس	Shimāli Qiṭus [Northern one of the Cetus]	356°	11° S	8 ι Ceti	1°	11° S
40	قيطس جنوبی	Qiṭus Janubi [Southern one of the Cetus]	359°	21° S	16 β Ceti	7°	20° S
41	منكب الفرس	Mankab Al-Faras [Shoulder of the Horse]	355°	31°½ N	53 β Pegasi	342°	27° N
42	كف الخضيب	Kaff Al-Khaḍib [The blood-red hand]	329°	51° N	11 β Cassiopæ	355°	55° N

The following notes on some of the stars given in the preceding list are added to give some idea of the knowledge of the celestial sphere as known to the Arabs., and also their identifications according to modern star-maps. The only important costellation left out in this list is the constellation of Hercules-Al-jâthi الجاثی or Al-jâthi 'ali rakbatih الجاثی علی رکبتیه *i. e.* one sitting on his knees :—

A. The Arabs seem to have copied verbatim the word Cetus (Sea-monster) into قیطس Qiṭus, which is a prominent constellation just south of the Celestial Equator, and has a beautiful variable stars o Ceti (Mira). The other three stars of the same constellation as given in our list are-Fom al-Qitus, Qitus Shamâli, and Qitus Janubi, Nos. 4, 39 and 40.

B. Masalsalah (مسلسه) is the well-known constellation of Andromeda or Chained Lady, otherwise known as 'zan bâ zanjir' (زن با زنجیر). The reading Janb Amsala is not correct.

C. Al-Ghūl (الغول is the well-known star so called because of its variable magnitude in the constellation of Perseus (پرساوس Parsāus) representing the Head of Medusa, held by Perseus in his right hand. The popular name Algol is the westernized form of the original Arabic "Al-Ghul".

D. Nahr (نہر = river) is the long thin constellation of Eridanus of which the most conspicuous star towards the south is Âkhar-un-Nahr (آخر النہر = end of the River), the Arabic name being corrupted into "Acherner", α Eridani.

E. Al-Thûr (الثور = the bull) is the constellation of Taurus, the second one of the signs of the Zodiac ; and 'Ain-Al-Thūr (عین الثور = the eye of the Bull) is the principal first magnitude star of Taurus (α Tauri), popularly known as Aldebaran. Al-Debbaran according to the Arabs means the star-group Hyades or the five chief stars of the Hyades, the brightest of which is Aldebaran. These five stars are said to be the Bull's hump. Al-Debbaran constitutes the Fourth Lunar Mansion. The other prominent object in the same constellation is Al-Thūrrayā (الثریا) popularly known as the Pleiades (Pr. پروین parvin), which is the third Mansion of the Moon, and is one of the most spectacular objects in the Heavens ; this Lunar Mansion is considered most auspicious by the Arabs, perhaps of the abundance of rain at the time of its Naw' (نوء). Its principal star is Alcyone (η Tauri).

F. Nos. 7, 8, and 10 are the first magnitude stars in the constellation of Orion (the hunter) known as Al-Jabbār (الجبار), and also as Al-Jauzā (الجوزاء); the latter is also the name of the Zodiacal constellation of Gemini. But to avoid ambiguity Orion is known as Niṭāq al-jauzā (نطاق الجوزاء) or Fiqār al-jauzā (فقار الجوزاء). It is named also Al-jabbār (الجبار) as it resembles the form of a crowned king upon a throne. **Hindus** call this constellation Mriga (मृग = a deer) and Canis Major, Vyâdha (व्याध = hunter) just the reverse of Orion, the hunter and Canis Major, the dog. The constellation of Gemini is sometimes called Al-ṭawwāyīm (التوآيم = the twins).

G. Al-'ayūq is the principal star Capella in the constellation of Auriga (the Charioteer), and designated by the Arabs as Mumsak al-anān (ممسك العنان = holder of the reins). Hindus designate this star by the name Brahmahridaya (ब्रह्महृदय)

H. Al-Shi'arī (الشعرى) is in general the brightest star in the Heavens viz. Sirius, also called Al-Marzam (المرزم). "It rises aurorally after Al-jauza (الجوزاء = Gemini) in the time of intense heat. When Sirius rises aurorally, the owners of palm trees begin to see what their fruits will be"—Lane. There are however two stars of the names—Al-Shi'arī al-'abūr (الشعرى العبور) and Al-Shi'ari al-ghumisā الشعرى الغميصا and both together are called Al-Shi'ariyān (الشعريان); the former (Sirius) is that which is after Al-jauza (الجوزاء), and the latter is Procyon (سگ مقدم sag-i-muqqadam = forward dog), and also as Dharra' muqbūsā (ذراع مقبوصى). Al-Shi'ari (الشعرى) is worshipped by a portion of Arabs, and hence God is said to be the Lord of Al-Shi'ari. Sirius is called Al-'abūr (العبور) because of its having crossed the Milky Way, and the other, Procyon is called Al-ghumiṣā (الغميصا) because (as said by the Arabs) to have wept after the former until it had foul thick matter (غمص) ghams in the corner of the eye. They are also designated, as in this list, Al-Shi'ari al-yamanih (the Yemenian or southern Shi'ari) and Al-Shi'ari al-shāmih (the Syrian or Northern Shi'ari).

"According to Arabs, both these Shi'aris are sisters of Suhil (سہیل' = Canopus) and the Yamanī crossed the Milky Way and turned his mujarah (مجره) towards him but the Shāmī remained in the same direction, was crying and injured his eys"—Lane.

I. Kalb al-akbar (کلب الاکبر) Canis Major and Kalb al-aṣghar (کلب الاصغر) Canis Minor are the constellations of which the principal stars are Sirius and Procyon respectively.

J. Shujjā'a (شجاع' = intrepid warrior) is the constellation of Hydra, the sea serpent, and its principal star is Al-Fard (α Hydra). Its popular name Al-fard is the exact verbatim of Arabic الفرد (al-fard = the solitary one).

K. Al-asad (الاسد = the lion) the Arab constellation of Leo, the lion, is more extensive than the one which we know at present by the name Leo. No. 16 is Cor-Leonis (heart of lion, α Leonis, Regulus and No. 20 is Denebola, corruption of Danab al-asad (ذنب الاسد = tail of the lion).

L. Bāṭih (باطیہ) is the name of the constellation of Crater, the cup. Literally "It is a large vessel of glass, which is filled with wine or beverage and placed amongst the drinkers, who ladle out from it into their cups and drink it"—Lane. No. 17 represents the bright star at the base of the cup, and No. 18 one near the bottom of the hollow of the cup.

M. Al-Dubb (الدبّ = the bear) is the constellation of Greater Bear (Ursa Major) so prominent by its seven conspicuous stars, known also as the Seven stars of the Plough. Hindus call it Saptṛishi (सप्तऋषि), each one of these stars being specifically designated by the name of a Vedic Rishi. Al-dubb, according to some represents the Lesser Bear. To avoid confusion, the former is called Al-dubb al-akbar (الدبّ الاکبر) and the latter Al-Dubb al-aṣghar (الدب الاصغر). This star, α Ursa Majoris, is popularly called Dubhe, which is a corrupted form of Arab. Dubb (دبّ).

N. This is really a Double Star and hence designated as Al-Ḥafan, its secondary being of a small magnitude. It is the Sixth of the seven stars of the Plough, viz., ζ Ursa Majoris and known to the Hindus by the name of Rishi Vasishta.

O. Al-Ṣurfah (الصرفه) is the 12th Lunar Mansion and forms a part of the constellation of Al-asad (Leo), its principal star being Denebola (β Leonis) see note K.

P. Al-Simākān (السماكان) is the general name for the two bright stars, Al-simāk al-rāmaḥ (السماك الرامح) and Al-simāk al-a'azal (السماك الاعزل). The former is the first magnitude star of the constellation of Bootës, the Herdsman and which is named by the Arabs as 'Awwa (عوّا = one who makes wow-wow noise), Pr. (بانگ کننده) and named Arcturus (α Bootes); whilst the latter is the first magnitude star of the Zodiacal constellation Virgo (Sumbale 'سنبله') and named Spica (α Virginis). 'Awwa is the Herdsman with rumaḥ ('رمح = a spear) and a staff, 'aṣā (عصا). No. 25 Tarf al-'aṣā, is the top of this 'asā (staff) which the Herdsman holds. Bootes is also called Ṣayyāḥ (صيّاح). Simāk al-a'azal is the 14th Mansion of the Moon, and is one of 'anwā' (انواء pl. of 'نوء naw'), and rises aurorally in October. It is called *a'azal* (اعزل) because there is no star near or before it like the A'azal (اعزل *i. e.* one who is unarmed), whilst the other Simāk is Rāmaḥ (رامح) *i. e.* armed with a rumah ('رمح = a spear). The three first magnitude stars Arcturus, Spica and Denebola, are approximately at the vertices of an equilateral triangle in the Heavens.

Q. Ghurrāb (غرّاب = a crow) is the constellation of Corvus, the crow, known amongst the Hindus by the name Hasta (हस्त = the hand), it being their 13th Lunar Mansion. The 13th Lunar Mansion of the Arabs is 'Awwā (عوّا) = β, η, γ, δ, ε, Virginis.

R. Fakkah (فكه) is a beggar's bowl and Al-fakka (الفكه = the bowl) is the name of the constellation of Corona Borealis, the Northern Crown. Naiyar Fakkah (نيّر فكه = the bright one of the bowl) is the principal star (α Corona Borealis) of this constellation, and popularly known as Alphecca. It is also called Iklil (اكل = a crown), or more specifically Iklil-i-Shimālī (Northern Crown), as there is another Iklil, Iklil-i-janūbī (Southern Crown) in the head of Scorpio β, γ, π Scorpio. (see Note T.)

S, Al-Ḥaiyah (الحيه = the serpent) is the constellation of Serpens, the serpent, and Al-Ḥawwā (الحوا) is the snake-charmer, the constellation of Ophiuchus. These are two adjacent constellations and generally these stars are so configured as if the snake-charmer has the snake in his hands. No. 27 is at the neck of the serpent, No. 28 at the elbow of the snake-charmer and No. 29 at his head. This constellation is quite distinct from another similar constellation Al-Tannin (التنين = the dragon) Draco, the dragon, lying between Ursa Major and Ursa Minor.

T. Al-ʻAqarab (العقرب = the Scorpion) is the 8th Zodiacal Constellation of Scorpio, the Scorpion, and contains three groups of bright stars as if forming the figure of a scorpion. At the middle of the body there is Qalb al-ʻaqarab (قلب العرب = heart of scorpion), α Scorpio, popularly known as Antares (a Greek word meaning looking red like Mars). The Head of the Scorpion forms the 17th Lunar Mansion, Iklīl (اكيل), better known as Iklil-i-janūbī the Southern Iklīl, to distinguish it from Iklīl-i shimālī- the Northern Iklīl, (see note No. R); the heart (qalb قلب) forms the 18th Mansion and the sting (shaulah شوله) forms the 19th Lunar Mansion. Hindu names for these Mansions are Anurādhā, Jyeshtha and Mūla.

U. Al-'uqqab (العقاب = the Eagle) is the constellation of Aquilla, the eagle, a very prominent constellation. The three middle stars of this constellation demarcate the 23rd Lunar Mansion of the Hindus, viz., Shravana and the middle bright-star is No. 33.

V. Nasr Al-waqiʻa (نسر الواقع = swooping eagle) and Nasr Al-Ṭāyar (نسرا لطا ئر = soaring eagle) are two bright magnitude stars in the vicinity of each other in the North; the former is the principal star of the constellation of Lyra, the lyre, α Lyrāe, popularly known as Vega; and the latter, the principal star of the constellation of Aquilla, the eagle, α Aquillae, known as Altair, an exact reproduction of the Arabic Al-Tāir. Both these stars form the 20th and 21st Lunar Mansions of the Hindus, viz. Abhijit and Shravana; whilst the Arabs have taken quite the different stars to represent the 20th and 21st Mansions viz. Ḍhābiḥ (ذابح) α, β Capricorni and Bula'a (بلع) ε, μ, ν Aquarii.

W. Al-Dalfin (الدلفين) is the constellation of Delphinus, the Dolphin, which forms the 24th Hindu Lunar Mansion viz. Dhanishta (धनिष्ट), whilst the Arab Mansion is Sa'ud (سعود) β, ζ, Aquarii.

X. Al-Jaddi (الجدّى) is the 10th Zodiacal Constellation of Capricornus, the goat. Hindu name is Makara (मकर = a kind of sea-animal). Danab al-jaddi demarcates the tail of the animal.

Y. Al-Dajjājah (الدّجاجه = the hen) is the constellation of Cygnus, the swan and consists of 19 stars in the figure of the bird (either a hen or a swan) and two stars outside the figure; four of these α, γ, η and β are in a row and lie on the Milky Way, whilst δ, γ, ε and ζ lie across the Milky Way. Danab-al-Dajjājah (دنب الدجاجه = the tail of the hen), α Cygni is also called Al-Ridif (الردف) as on the M. F. Library Astrolabe. No. 36 'Asirat al-Dajjājah (عاسره الدجاجه) is ζ Cygni on the wing of the hen and Ṣadra al-Dajjājah (صدرالدجاجه = breast of the hen) is γ Cygni. (see underneath for a note on "Al-Deneb").

Z. Qitus shimāli is also known as Danab Qitus (دنب قيطس = the tail) of Qitus).

AA. Sākib Al-Mā' (ساكب الماء = carrier of water) is the 11th Zodiacal constellation of Aquarius, the Water-bearer. It is also known as Al-Dilv (الدلو = the bucket).

BB. Al-Faras (الفرس = the horse) is the constellation of Pegasus, the winged horse. The square of Pegasus is a prominet figure in the sky near the celestial Equator and the first point of Aries. It is formed by three stars α, β, γ Pegasii and α Andromedae of the constellation of Andromeda, the chained lady. No. 41 Mankab Al-faras (منکب ا لفرس = Shoulder of the horse) is β Pegasii; (this star is sometimes vaguely called as Mankab only); 'Ain Al-faras (عین ا لفرس = Eye of the horse) is α Pegasii; and Jannāh Al-faras (جناح الفرس =wings of the horse) is γ Pegasii.

The star α Andromedae forming the fourth corner of the square is popularly known as Alpherat. The stars α, β, γ, Pegasii are popularly known as Markab, Scheat and Algenib respectively.

CC. The constellation of Cassiopeia, the lady in chair, is known as Ḍhat al-kursī (ذات الکرسی = master of the chair) or Khodavand-i-kursī (خداوند کرسی = lord of the chair). Khaḍib (خضیب) is the dye of Henna and the star is sometimes called Dast-i-ḥinā baste (دست حنا بسته = hand stained red by henna). This star is also known as Caph, perhaps from the first word "kaf" of the name.

DD. The word Danab (ذنب = the tail) occurs in several star names, such as, Nos. 20, 31, 34, 35, 37 and 40 in the list of stars, but of all these No. 37 alone Danab Al-dajjājah is popularly known as Al-deneb or Deneb.

This brings us to the end of the Description of the J. B. Petit Astrolabe, at present in the custody of the Mulla Feeroz Library.]

THE ASTROLABE IN THE MULLA FEEROZE LIBRARY.

NOTE

[Khan Bahadur Prof. Abdul Kadar Surfraz has pointed out that a description of the Astrolabe in the Mulla Feeroze Library has been published by late Prof. E. Rehatsek in his paper in the Journal of the Bombay Branch of the Royal Asiatic Society, Vol. XI, pp. 327-329, with ten Lithographed diagrams, in 1875. It is not known whether late Mr. M. P. Khareghat knew about it when he wrote out his description of the same Astrolabe. However the presumption is that he did not know it. For if he had known it, he would not have left undeciphered the tablet on the *Kursi* of this Astrolabe which Prof. Rehatsek has deciphered, and given the reference to the preface of the Gulistān of Sā‘di for that quotation.

Again it is curious that such an erudite scholar of both Persian and Arabic languages as Prof. Rehatsek, should have misread some of the names on the Astrolabe and given the readings as he had given. These can be briefly pointed out as under :—

(a) Of the names of the towns with longitudes and latitudes as given on the mater, Amul is read as Amed, Sabzwār is read Shirwān, and Maini and Khotan are omitted;

(b) The number of stars within the circle of the Ecliptic as given on the ‘*Ankbūt* (aranea) is eleven, while Prof. Rahatsek has given only nine, and some readings do not seem to be proper, thus—

(i) Mankab (shoulder of horse) (β Pegasus), (ii) Simāk Rāmaḥ, (Arcturus), (iii) Fum-al-faras (mouth of Pegasus) ε Pegasis, (iv) ‘Unak al-ḥayiah (neck of serpent) α serpens, (v) Nasra-wāqi‘a (swooping eagle, Vega) are correctly given; but (vi) Rās al-ḥawwā (Head of Ophiucus, α Ophiuci) is read Ras al-ḥut (head of the fish), (vii) Nasra-tāyir (soaring Eagle, Altair, α Aquilla) is read as al-sarṭān (Cancer, the Crab), (ix) Ẓahr-ad-dubb (α Canis major) is given as ad-dubb only, whilst (x) Naiyar Fakkah (Alphecca, α Corona Borealis) and (xi) Radif (tail of swan, α Cygnus) are omitted.

(c) The number of stars outside the circle of the Ecliptic is thirteen whilst only ten are given by him as under—

(i) Jannāh al-ghurrāb (wings of the Crow), (ii) ‘Ain al-thūr (the Bull’s eye, α Tauri, Aldabaran), (iii) Ḳalb-al-asad (heart of Lion, Regulus, α Leo), (iv) Rajal al-yasari (left-foot of Orion, Rigel), (v) Kalb al-‘aḳarab (heart of Scorpion, Antares, α Scorpio), (vi) Dhanab Qitus (tail of the whale) are properly given ; but (vii) Fard al-shujjā‘a (α Hydra) is read Fard ahā‘; (viii) Shi‘rah Shāmi (Procyon) is read shi‘ar shāmi; (ix) sāk yamani (leg of Aquarius) is read shāvaime; (x) Simāk al-a‘azal (Spica), (xi) Qā‘ide (al-bātiyah) (α Crater), (xii) Shi‘rah yamāni (Sirius) and (xiii) Yadd-i-yamāni (Betelgeux)—are omitted.

Further a star ذراع Dharrā‘ is given but it is not known how this name is obtained.

It need hardly be said that the orthography of names in the Litho-diagrams is not very satisfactory.

Further this astrolabe is simpler than the one already described and it lacks in several details. Under the circumstances, it is not necessary to encumber its description with details which have already appeared in the previous account. References, however, have been given to places where the required explanatory notes can be referred to.]

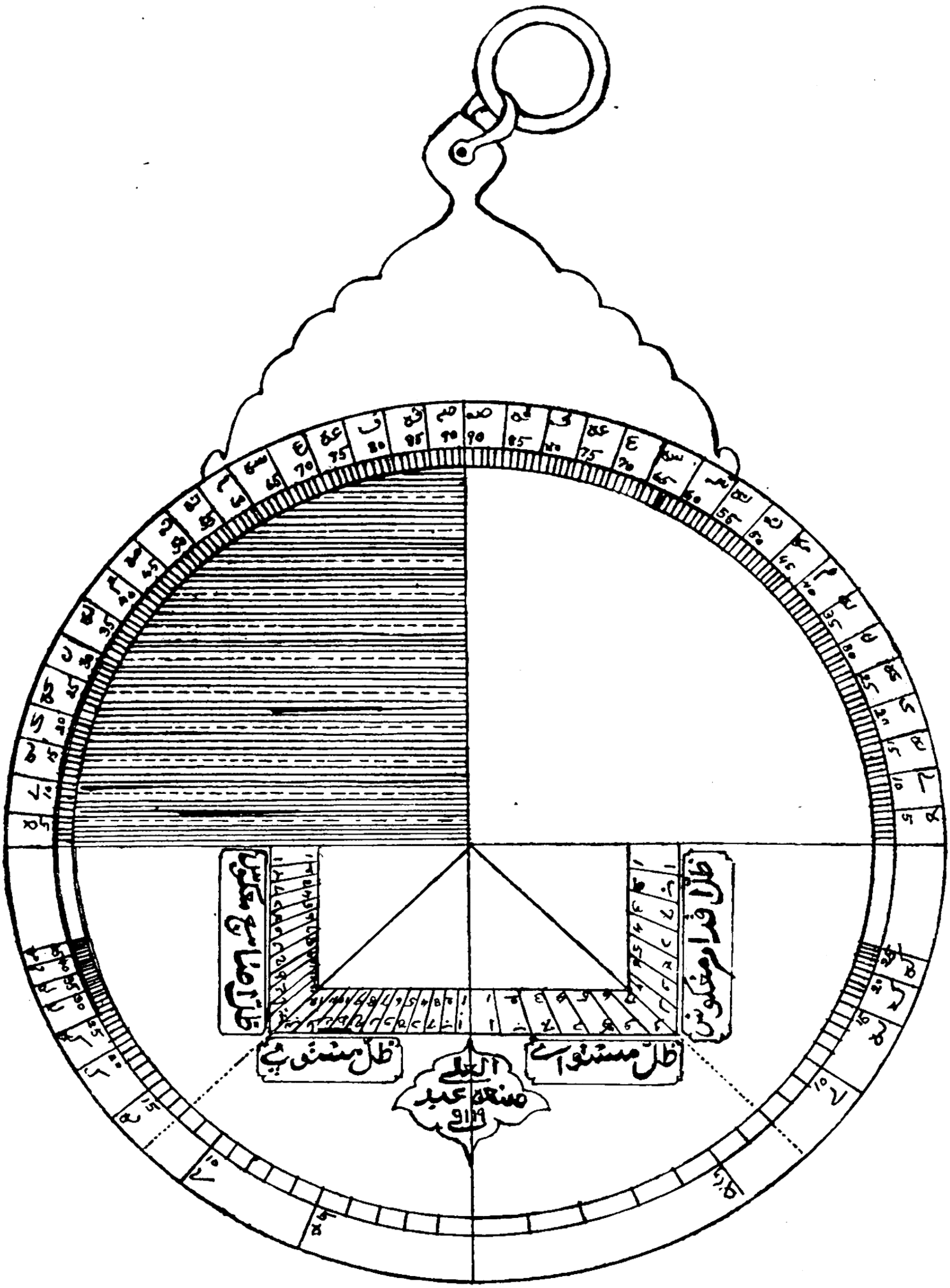


Fig 10— The Back of the MFI Astrolabe.

ASTROLABE IN THE MULLA FEEROZE LIBRARY
22-9-1925.

Mater (اُمّ umm), Diameter—5.2″ or 132.5 mm. Thickness 8 mm.

Back (ظهر Zahr)—The four quadrants are as under —

Quadrant A—Outermost circle is double, its exterior diameter being that of mater. Next inner circle is also double, its exterior diameter being 119.5 mm. Third inner circle is single and of 114.5 mm. diameter.

Between the outermost double circle and the second double circle is the first ring: it is divided into groups of 5° each and measured as usual from the horizontal to the top as 5° (ه) to 90° (ص) in Abjad notation.

Between the second double circle and the inner circle is the second ring, divided into degrees but without numbers. The rest of the quadrant is vacant.

Quadrant B—Its outer part is exactly like Quadrant A, with two rings, marked and numbered into marks and degrees.

On the inner side are 60 equidistant lines parallel to the horizontal diameter, forming the sine (جيب jaib) scale. There are 60 divisions along the vertical radius; and the parallel lines are drawn from there: the divisions seem meant to be equal but they are not exactly so: every fifth line is a dotted one for facilitating counting.

Quadrants C & D—They contain the usual shadow scales, both rectangular and circular (see figure 1).

The Rectangular Scale consists of a rectangle, 57 x 28.5 mm. with its upper side coinciding with the horizontal diameter and bisected at the centre. In the left quadrant is the scale for "digit shadows" *i. e.* the shadows of a gnomon 12 digits in length when the sun is at any altitude from the horizontal line.

On the left side of the rectangle in a vertical ornamental tablet are marked the words (zill-i-aṣābi‘a m‘akūs ظل اصابع معکوس) *i. e.* inverted shadows in digits: and within the rectangle are marked divisions from 1 to 12 (ا to يب) in the Abjad notation, from the horizontal line upto an altitude of 45°: below the left half of the inner side are placed the words ظل مستوی (zill-i- mustawi) *i. e.*

direct shadows, and along it, from 45° to the vertical diameter, are marked divisions from 12 to 1 (ب to ا). Similarly the right side of the rectangle shows the shadows in feet of a gnomon stick 7 feet in length: on the right side are written vertically the words ظل اقدام معکوس (zill-i-aqdām m'akūs) *i. e.* inverted shadows in feet, with divisions from 1 to 7 (ا to ز), from the horizon to an altitude of 45°, and below the lower side are the words ظل مستوای (zill-i-mustawāi) *i. e.* direct shadows with divisions from 7 to 1 (ز to ا) from 45° to 90°.

Under the rectangle, right in the centre are given the name of the maker and year. These particulars are enclosed in an ornamented figure as under:—

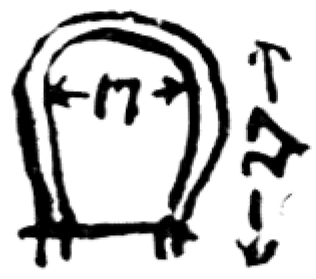
i. e. صنعه عبدالعلی ۱۱۹ فی (sanu'hu'Abdal-'Ali fi 119) *i. e.* "Abdul Ali made it in year 1190", and as it sometimes happens, the last cypher of the year is not given here. (The year also appears on the face over the Kursi (کرسی) as will be seen later).

The Circular Scales are along the circumference of the two quadrants consisting of two rings. The inner ring on the left is divided into parts which correspond to each digit of shadow, and the outer ring is divided into groups of five such parts and numbered from below as ه (5), ی (10), یه (15), ك (20), كه (25), ل (30), له (35), م (40), and مه (45): naturally 12 divisions correspond to an altitude of 45°, and 45 divisions correspond to an altitude of about 14°. [Note $\tan 45° = \frac{12}{12}$ and $\tan 14° \; 55' = \frac{12}{45}$]

Similarly the inner ring in the right quadrant is divided into parts corresponding to each foot of shadow, and the outer ring into groups of five such divisions and numbered from below ه (5), ی (10), یه (15), ك (20), كه (25): in this case 7 divisions correspond to an altitude of 45°, and 25 divisions correspond to an altitude of 15° [Note $\tan 45° = \frac{7}{7}$ and $\tan 15° \; 39' = \frac{7}{25}$]

(vide pp. 7-10 for fuller explanatory notes)

The halqa (حلقه) is about 20 mm. in diameter and the 'urwa (عروه) which is like a hook and revolves on a pin passing through the hole near the top of the Kursi and is about 17 mm. broad near the upper end, and 27 mm. long.



The Kursi (کرسی) is about 75 mm. at the bottom and projects 45 mm. from the mater.

On the Kursi, and in front of the Astrolabe, in an ornamental figure is given the following tablet, which I cannot make out quite clearly at present.

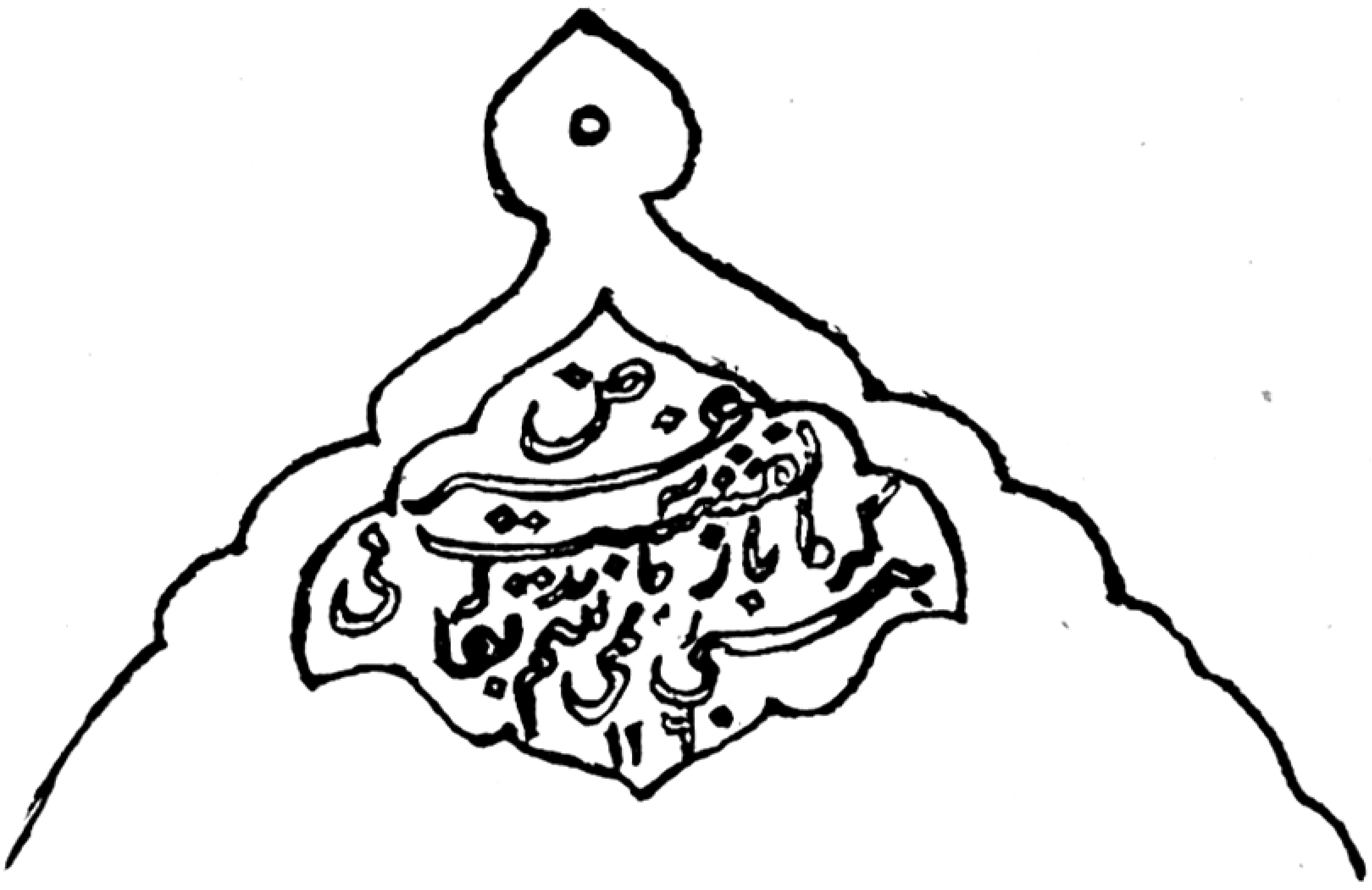


Fig. 11 The Inscription on the 'Kursi' of the MFL Astrolabe

[The Tablet is as under which reads :—

غرض نقشیست کز ما باز ماند
که هستی را نمی بینم بقائی

i. e. gharaḍ naksh-ist
kaz mā bāz mānad
ke hasti rā nami-binam
baqāyi

meaning—the aim is to produce a work in engraving which may remain long after us,—for I do not see any permanency in this material world.

It appears from the rough notes left by late Mr. M. P. Khareghat that he had nearly succeeded in deciphering the lines. His notes and the correct reading can be placed side by side as under—

	M. P. K.'s attempt	***Present reading.***
1st line	....	gharaḍ
2nd line	Naksh ast	naksh-ist
3rd line	Be Digar Māra Bāz mānad	Kaz mā bāz mānad ke
4th line	Hasti Na Mi Binim Baqāyi	Hasti rā nami-binam baqāyi
5th line	1190	1160

As hinted before, if he had known about the paper on this Astrolabe already published by Prof. Rehatsek, he would have completed his decipherment very easily.

As pointed out by late Prof. Rehatsek and Prof. A. K. S. Shaikh, this couplet is the middle one of the three memorable couplets given by the famous poet Shaikh Sā'adi in his "Gulestān", about the end of his preface to it. They are as under :—

نماند سالها این نظم و ترتیب ❊ زما هر ذرهٔ خاك افتاده جائی
غرض نقشیست کز ما باز ماند ❊ که هستی را نمی بینم بقائی
مگر صاحبدلی روزی به رحمت ❊ کند در کار درویشان دعائی

The date given on this tablet on the Kursi is obviously ١١٦. *i. e.* 1160, which Mr. M. P. K. reads as ١١٩. *i. e.* 1190, perhaps guided by the figures without the last cypher, as given at the back of the Astrolabe along with the name of the maker. This produces some confusion and leads to uncertainty about the date of manufacture of the instrument. Mr. M. P. Khareghat suggests the last cypher is not given, as is the general custom in such cases. But the figures ١١٩ as engraved at the back, are of a type quite different from the type of characters mostly used nearly on all the pieces of the Astrolabe. Perhaps the engraver engraved 9 so carelessly as to make it appear like ٦ (6). The date, therefore, could not be definitely fixed: but this astrolabe is about hundred years more modern than the other one which was manufactured in 1070 A.H.

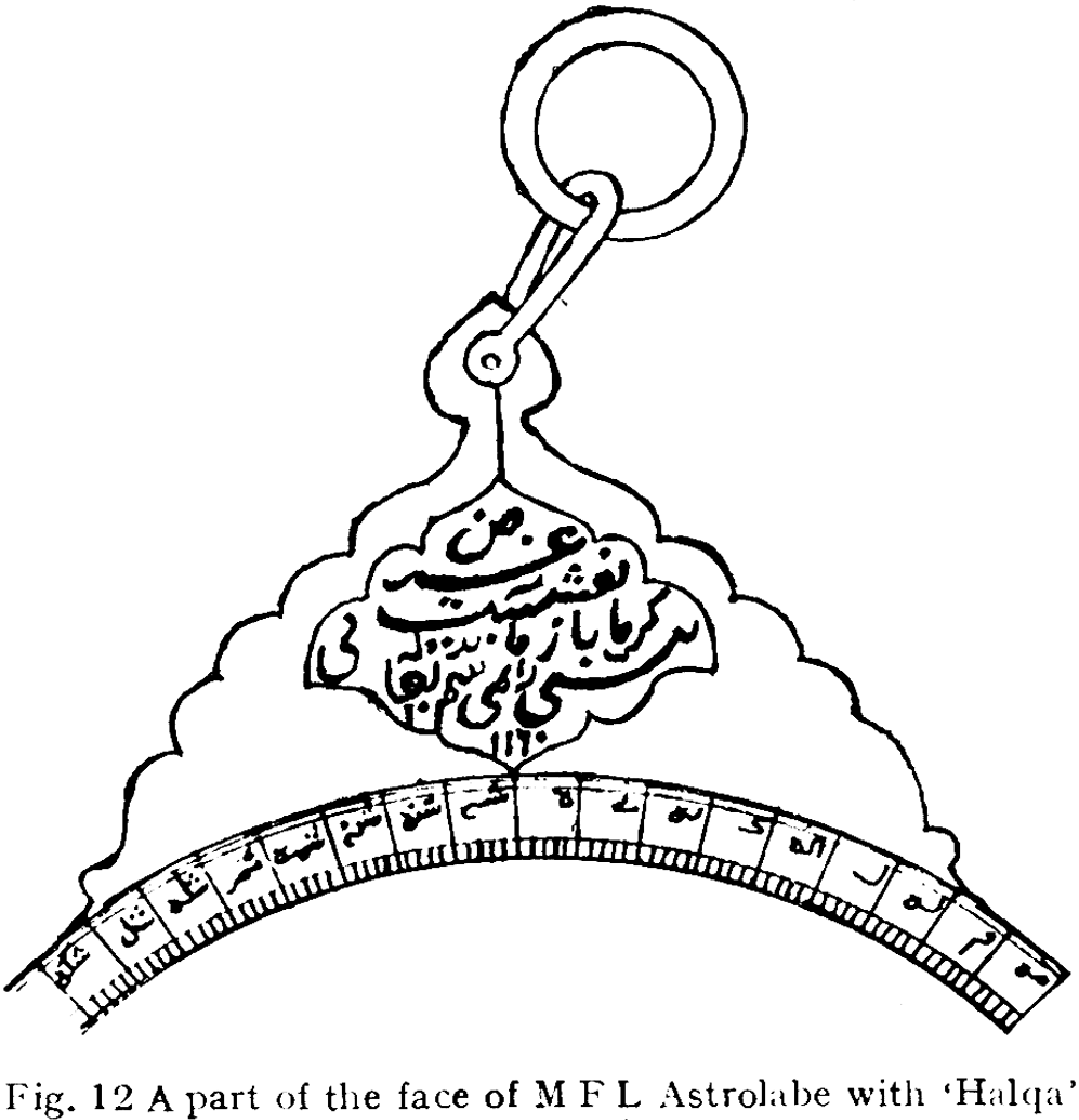


Fig. 12 A part of the face of M F L Astrolabe with 'Halqa' & 'Urwah'

Face—The details of the front of the Astrolabe, which is a circular projecting disc with a triangular ornamental head-piece called the Kursi (كرسی) are as under

The outer diameter of the face is almost 133 mm., inner diameter 116.5 mm.

On the margin are two rings, the inner one being divided into 360° degree, but without numbers, and the outer one into groups of 5, and numbered, beginning from the top in clock-wise direction, from 5 to 360, according to Abjad notation. The numbers are...

ه	(5)	ق	(100)	قص	(190)	رف	(280)
ے	(10)	قه	(105)	قصه	(195)	رفه	(285)
یه	(15)	قے	(110)	ر	(200)	رص	(290)
ك	(20)	قیه	(115)	ره	(205)	رصه	(295)
كه	(25)	قك	(120)	رے	(210)	ش	(300)
ل	(30)	قكه	(125)	ریه	(215)	شه	(305)
له	(35)	قل	(130)	رك	(220)	شے	(310)
م	(40)	قله	(135)	ركه	(225)	شیه	(315)
مه	(45)	قم	(140)	رل	(230)	شك	(320)
ن نه	(50)	قمه	(145)	رله	(235)	شكه	(325)
نه	(55)	قن قنه	(150)	رم	(240)	شل	(330)
س	(60)	قنه	(155)	رمه	(245)	شله	(335)
سه	(65)	قس	(160)	رن	(250)	شم	(340)
ع عـ	(70)	قسه	(165)	رنه	(255)	شمه	(345)
عه	(75)	قع	(170)	رس	(260)	شن	(350)
ف	(80)	قعه	(175)	رسه	(265)	شنه	(355)
فه	(85)	قف	(180)	رع	(270)	شس	(360)
ص	(90)	قفه	(185)	رعه	(275)	شسه	

On the Venter—There are eight concentric zones: the fourth and the eighth zones from the outside are vacant.

The First contains the names of places (al-bilād) البلاد, the second their longitudes (al-ṭūl) الطول, and third their lutitudes (al-arūḍ) العروض; similarly the 5th, the 6th and the 7th zones contain respectively the names of places, their longitudes and their latitudes. The headings (al-bilād) البلاد etc., in both the sets begin from the top and the names are given from right to left in counter clockwise direction.

[For the sake of comparison of the values of longitudes and latitudes as given on the Astrolabe, with modern Geographical values of the same co-ordinates, last two colums are added. Also as mentioned previouslypp. 24,25 the longitudes of the Orientals are measured from a point in the "I'sle de fer", about 35 West of Greenwich. Several of the towns are common to both the Astrolabes, but this Astrolabe contains some additional towns of India indicating perhaps its Indian origin.]

No.	(Al-bilād) البلاد	Towns	At-ṭūl الطول	Al-arūḍ العروض	Longitude as on the Astrolabe	Latitude as on the Astrolabe	Longitude as in Modern Books	Latitude as in Modern Books	Remarks
OUTER RIM									
1	مكّه	Mecca	عز ي	كا م	77°-10′	21°-40′	40°-17′ E	21°-30′ N	
2	مدينه	Medina	عه ك	كه ها	75°-20′	25°- 0′	40°- 0′ E	24°-25′ N	
3	كاشان	Kāshān	فو ها	لد ها	86°- 0′	34°- 0′	51°-22′ E	33°-58′ E	
4	اصفهان	Iṣfahān	فو م	لب كه	86°-40′	32°-25′	51°-36′ E	32°-44′ N	
5	قزوين	Qazvin	فه ها	لو ها	85°- 0′	36°- 0′	49°-59′ E	36°-19′ N	
6	ساوه	Sāvah	فه ح	له ح	85°- 8′	35°- 8′	50°-16′ E	34°-59′ N	
7	همدان	Hamadān	فج ها	له ي	83°- 0′	35°-10′	48°-18′ E	34°-50′ N	
8	زنگان	Zangān	فج م	لو ل	83°-40′	36°-30′	48°-32′ E	36°-40′ N	
9	نهاوند	Nihāvand	فج يه	لد ك	83°-15′	34°-20′	48°-17′ E	34°- 6′ N	
10	اصطخر	Iṣṭakhar	فح ل	له ها	88°-30′	35°- 0′	52°-55′ E	29°-52′ N	Persepolis
11	شراز	Shirāz	(A) فج ها	كط لو	83°- 0′	29°-36′	52°-36′ E	29°-33′ N	
12	كازرون	Kāzrūn	فز ها	كط يه	87°- 0′	29°-15′	51°-40′ E	29°-38′ N	
13	بصره	Buṣrah	فد ها	ل ها	84°- 0′ (B)	30°- 0′	47°-50′ E	30°-34′ N	
14	بغداد	Baghdād	فب ها	لج كه	82°- 0′ (B)	33°-25′	44°-30′ E	33°-18′ N	
15	اردبيل	Ardbil	فب ل	لح ها	82°-30′	38°- 0′	48°-30′ E	38°-12′ N	
16	تبريز	Tabriz	فب ها	كح ها	82°- 0′	38°- 0′	46°-22′ E	37°-59′ N	
17	مراغه	Marāghah	فب ها	لز ك	82°- 0′	37°-20′	46°-19′ E	37°-16′ N	
18	نخچوان	Nakhchivān	فا يه	لح م	81°-15′	38°-40′	45°-30′ E	39°-15′ N	
19	دمشق	Damishq	ع ها	لج يه	70°- 0′	33°-15′	36°-20′ E	33°-30′ N	
20	آستراباد	Astrābād	فط له	لو ن	89°-35′	36°-50′	54°-27′ E	36°-48′ N	
21	سارى	Sāri	فح ها	لو ها	88°- 0′	36°- 0′	53°- 2′ E	36°-33′ N	

22	آمل	Āmul	فح ک	لو یه	88°-20′	36°-15′	52°-15′ E	36°-30′ N	
23	رے	Rae	فو ک	له ها	86°-20′	35°- 0′	51°-30′ E	35°-30′ N	
INNER	RIM								
24	کاشغر	Kāshghar	قو ل	(C) مد ها	106°-30′	44°- 0′ (C)	76°- 0′ E	39°-30′ N	
25	خجند	Khojand	قد له	ما نه	104°-35′	41°-55′	69°-35′ E	40°-15′ N	
26	سمرقند	Samarqand	(E) سط او	لط لز	69°-16′	39°-37′	66°-55′ E	39°-40′ N	
27	بلخ	Balkh	(F) کا ها	لو ما	21°- 0′	36°-41′	67°- 5′ E	36°-46′ N	
28	قاین	Qāin	صح ک	لح م	93°-20′	33°-40′	59°-10′ E	33°-42′ N	
29	تون	Tūn	صب ل	لد ل	92°-30′	34°-30′	58°- 7′ E	34°- 2′ N	
30	طوس	Ṭūs	صب ل	لو ح	92°-30′	36°- 8′	59°-15′ E	36°-30′ N	
31	سبزوار	Sabzwār	صا ل	لو نه	91°-30′	36°-50′	57°-40′ E	36-°20′ N	
32	(G) آستراباد	Astrābād	فط له	لو نه	89°-35′	36°-50′	54°-27′ E	36°-48′ N	
33	کشمیر	Kāshmir	(K) قح ها	له ها	108°- 0′	35°- 0′	74°-59′ E	34°-12′N	(Srinagar)
34	احمد آباد	Ahmedābād	فح م	کب نب	108°-40′	22°-52′	72°-38′ E	23°- 3′ N	
35	گجرات	Gujrāt (M)	longitude and latitude not given						
36	کنبایت	Kambāyat	(L) قط ك	(H) کو ک	109°-20′	26°-20′	72°-38′ E	22°-22′ N	(Cambay)
37	سورت	Surat	قی ه	ک یه	110°- 5′ ?	20°-15′	72°-55′ E	21°-12′ N	
38	بروج	Broj (ch)	قا ه	کا ك	110°- 5′ ?	21°-20′	73°- 3′ E	21°-45′ N	(Broach)
39	چوتپور	Chotpur	(I) قیط و	کو لو	119°-16′ ?	26°-36′	73°- 5′ E	26°-20′ N	(Jodhpur)
40	داکه	Dākkah	قد	که ها	104°- 0′	25°- 0′	90°-30′ E	23°-46′ N	
41	بنگال	Bengal (M)							
42	میینے	Maini	longitude and latitude not given						
43	بدخشان	Badakshān	(.) قد کد	لز ی	84°-24′	37°-10′	70°-40′ E	37°-10′ N	(Faizabad)
44	بخارا	Bokhārā	صز ل	لط نه	97°-30′	39°-50′	64°-35′ E	39°-45′	
45	ختن	Khotan	longitude and latitude not given						(Cathay)

NOTES

(A) فح instead of فحـ would be more correct.

(B) Longitudes of Baṣrah and Baghdād ought to be less than those given on the Astrolabes.

(C) Latitude of Kāshgar is about 4°½ in excess.

(E) Through mistake the engraver has put سط (69) for صط (99); سط gives the longitude very much less. As both the words have the same pronunciation, the mistake is likely to occur; vide the next note.

(F) کا (21) seems to have been substituted for قا (101) as both the words have the same pronunciations, resulting in such a small value for the longitude.

(G) This is repetition of No. 20.

(H) This ought to be قح, the two dots seem to have been dropped.

(I) ود is probably قد, the two dots having been dropped.

(J) کو (26) seems to have been engraved for کد (24).

(K) قط (109) would suit better than قیط (119).

(L) قد (104) will be more appropriate than فد (84).

(M) These being names of Provinees, latitutes and longitudes cannot be given.

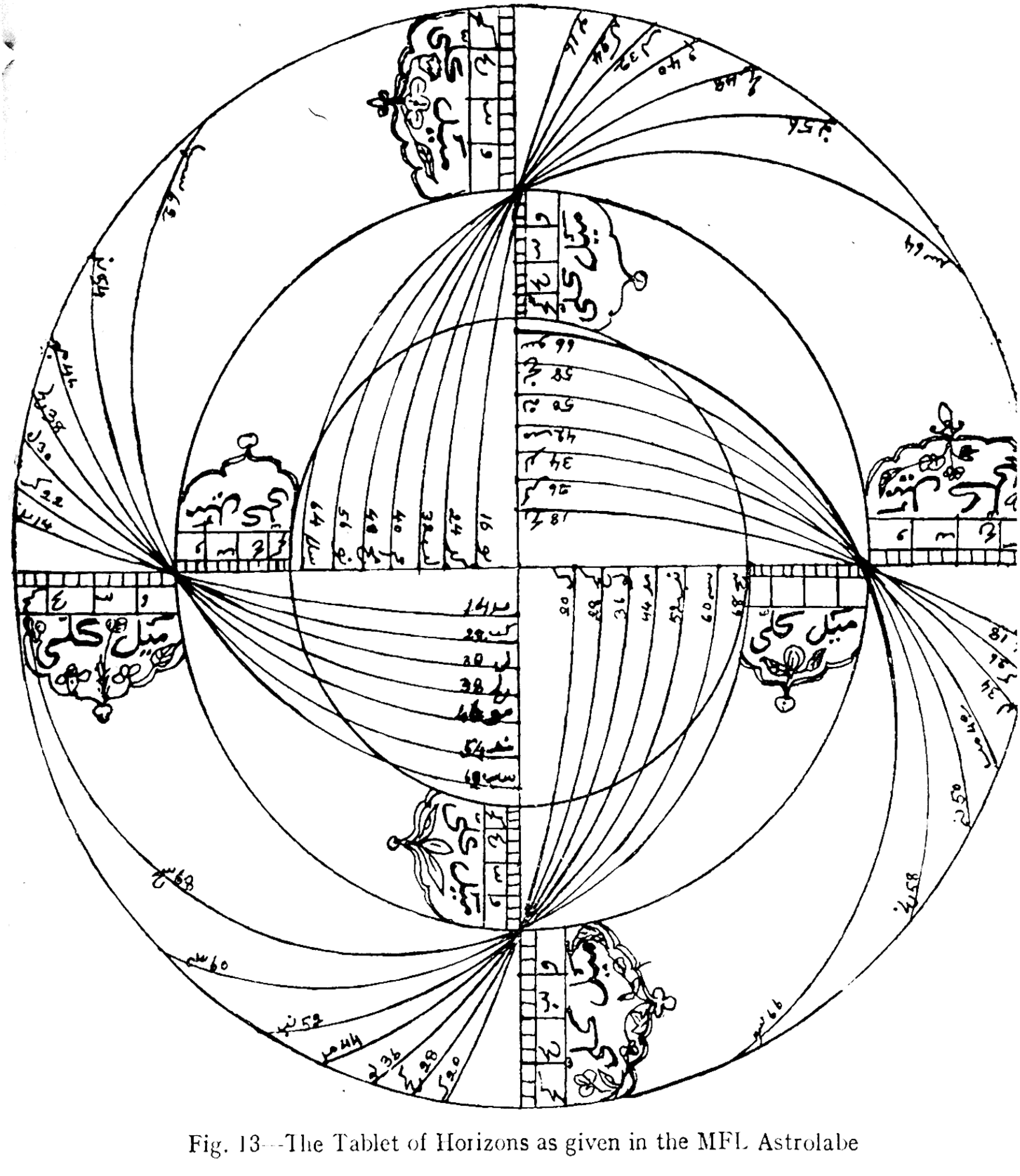


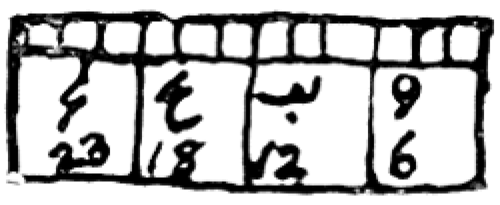
Fig. 13—The Tablet of Horizons as given in the MFL Astrolabe

TABLETS. (صفايح Ṣafāyaḥ)

This Astrolabe contains 5 Tablets or discs, each 116 mm. in diameter. The respective diameters of the Tropic of Capricorn, Equator, and Tropic of Cancer are in each 48 mm., 72 mm., and 110 mm.

Tablet I (a): is the tablet of horizons, although not so marked. It is like Kay's D.M.A.I. (Fig. 22), the horizons extending *only through two* quadrants (see also Tablet fig. 4). It is also similar to Tablet I (a) of the J. B. P. Astrolabe previously described. The left upper and left lower quadrants contain the horizons for every 8° of latitude from 14° to 62°, viz. يد (14°), كب (22°), ل (30°), لح (38°), مو (46°) ند (54°) and سب (62°); the right upper and the left upper quadrants contain the horizons for every 8° of latitude from يو (16°) to سد (64°); the right lower and the right upper from يح (18°) to سو (66°); and the left lower and the right lower from ك (20°) to س (60°)

Between the Equator and each of the Tropics are marked along each of the radii the points where the circles of Declination cut their radii for every 2° from 6° to 23° (و , يب , يح and كج), with the words (in floral ornamental styles) ميل كلى (mail-i-Kulli *i. e.* full Inclination); they are written 8 times thus



ميل كلى

which give the measures of inclinations upto 23° *i.e.* nearly upto the obliquity of the Ecliptic.

Tablet I (b) for 18° of latitude (عرض يح) and Day length 13 hours and 12 mts. (ساعات يج ب)

The Almuqantarāts (circles of altitudes) are marked for every 2°, upto 84° of altitude in the Abjad notation.

The Azimuth circles are marked for every 10° along the horizon from 0° to 90°, 90° to 0°, 0° to 90° and 90° to 0° in clockwise direction.

In the lower part, the *Temporal* hours are marked by continuous lines and numbered in numerical figures 1 to 12 from left to right, whilst the *Equinoctial* hours are shown by dotted lines, and numbered in Abjad letters ا to يد (1 to 14).

The ends مشرق (mashriq *i. e.* East) to the left and مغرب (maghrib *i. e.* West) to the right are marked and written as usual; and floral decorations are engraved in the lower part of the circle enclosed by the Tropic of Cancer.

Tablet II (a) for Latitude 22°-0′ (عرض كب ها), and Day length, (ساعات ...... كب) *i. e.* probably 13 hours–22mts; but the hours are not visible. [A closer examination discloses some such words as كب (22) and يد (14). The calculated day length for latitude 22°, is about 13 hours and 21 mts., and hence the engraver probably seems to have missed his mark, and instead of (يج كب) *i. e.* 13-22), engraved (كب يد) (*i. e.* 22-14)] The rest of the tablet is similar to that in Tablet I (b) .

Tablet II (b)—for Latitude 32° (عرض لب) and Day length 14 hrs. 7 mts. (ساعات يد ز). It is just like Tablet I (b), but the Temporal hours are marked in full words as الاولى (al-awwali = the first); الثانية (al-thāniyah = the second; الثالثه (al-thālitha = the third); الربعه (al-rābi'a = the fourth); الخامسه (al-khāmisa = the fifth); السادسه (al-sādisa = the sixth); السابعه (al-sābi'a = the seventh); الثامنه (al-thāmina = the eighth); التاسعه (al-tāsi'a = the ninth); العاشره al-āshira = the tenth); الحادی عشر (al-hādi 'ashr = the eleventh; الثانیه عشر (al-thāniya'ashr = the twelfth).

All the muqanṭara circles are marked and numbered, except the circles corresponding to 86° and 88°, which are not marked.

Tablet III (a)—for Latitude 25° (عرض كه) and Day length 13 hrs.......mts. not visible. [Calculated Day-length is 13 hrs. 34 mts.] Otherwise in all respects it is like Tablet I (b).

Tablet III (b)—for latitude 36° (عرض لو) and Day length 14 hours but minutes are not clearly visible (...... ساعات يد) [Calculated Day-length is 14 hours 27 mts.]. Rest as in Tablet I (b).

Tablet IV (a)—for Latitude 29° (عرض كط) and Day-length (ساعات) not visible. The rest as in Tablet I (b). [Calculated Day-length is 13 hrs. 52 mts.]

Tablet IV (b)—for Latitude 34° (عرض لد) and Day-length 14 hrs., minutes not visible (...... ساعات يد) [A closer examination suggests the figure كب (22), and if we therefore assume its presence, the Day-length comes to (ید کب) *i. e.* 14 hrs 22 mts. The calculated Day-length is 14 hrs. 17 mts.] Rest as in Tablet I (b). Muqanṭrāts are numbered upto (عو) 76°, although marked upto 88°.

Tablet V (a)—for Latitude 38° (عرص لح), Day-length 14 hrs. 40 mts. (ساعات ىد م). Temporal hours are only marked and Equinoctial hours are not marked at all; otherwise as in Tablet I (b).

Tablet V (b)—for Latitude 40° (عرض مه), Day-length 14 hrs. 51 mts. (ساعات ىد ٮا) (ٮا must be read نا (51) and not يا (11).
[It will be generally noticed that the engraver has not cared to put down dots for the various letters; calculated Day-length comes to 14 hrs and 51 mts.] The rest as in Tablet No. I (b).

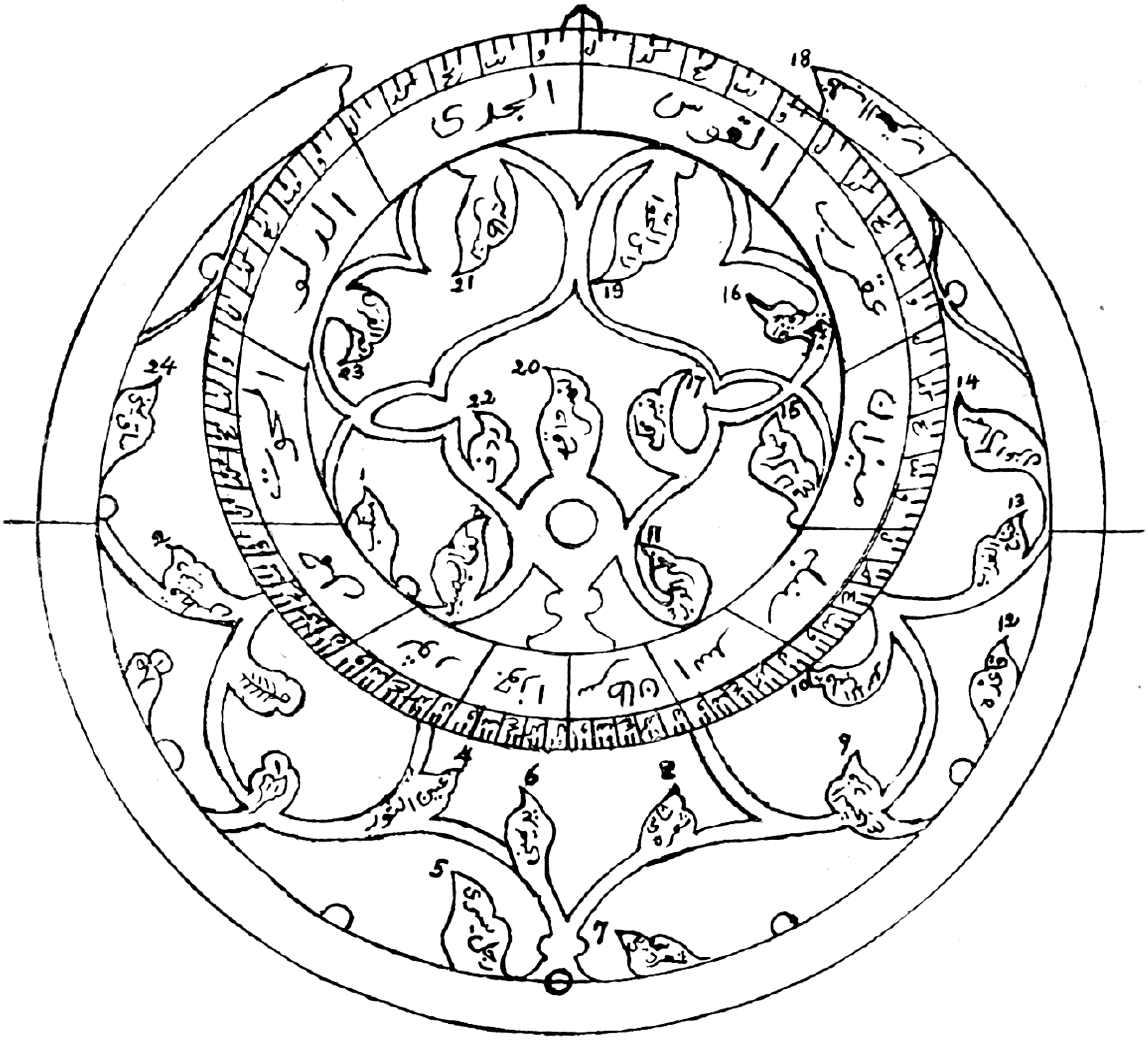


Fig. 14—The, 'Ankabūt of the MFL Astrolabe.

THE 'ANKABŪT (عنكبوت = Spider)

[The 'Ankabūt of this Astrolabe is simpler than the one in J.B.P. Astrolabe. The latter has been fully described on pp. 42-43. Suffice it to add that this 'ankabūt has only 11 stars marked down within the circle of the Ecliptic and 13 stars outside the Ecliptic *i. e.* in all 24 stars; whilst J. B. P. Astrolabe had 42 stars on its 'Ankabūt. Further as there is a difference of about 100 years between the dates of their manufacture, the co-ordinates of the stars on these 'ankabūts are bound to vary.

Mr. M. P. K gives in separate columns the Declinations and the Right Ascensions of these 24 stars, but he does not give any inkling as to how he has obtained these co-ordinates of the stars. This Astrolabe has neither (i) the Disc of Declinations and Right Ascensions (See fig. 6) nor (ii) the one for Latitudes and Longitudes (see fig. 5A-5B as previously described on pp. 31-32. Also no attempt seems to have been made to identify these stars, as what had been attempted for the J. B. P. Astrolabe. Hence in order to complete the information, Latitudes and Longitudes of these stars have been attempted by a disc like fig. 5, prepared to scale specially for the purpose, and also their possible identifications with the known stars in Modern star-charts are suggested. The last three columns are thus supplemental to the Tables originally given by Mr. M. P. Khareghat. The stars in this list are all included in the previous star-list of J. B. P. Astrolabe, and hence a reference back to pp. 42-50, will explain everything about these stars, and further explanations are therefore not necessary.]

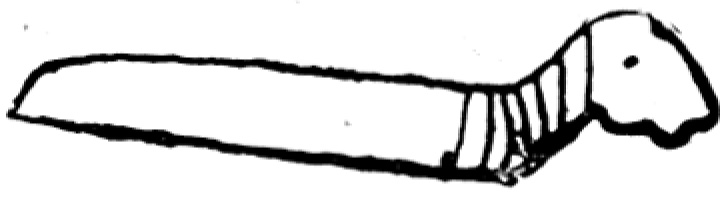
The Diameter of the whole 'Ankabūt is 116 mm. the inner diameter of the outer ring is 106 mm., the diameter of the Ecliptic is 79 mm. Its rough reproduction is as per figure 14 attached.

LIST OF STARS ON THE 'ANKABŪT.

Name	Right Ascension	Declination	Longitude	Latitude	Remarks
1. منكب Mankab [shoulder (of the winged horse)].	353°	25°N	335°	30°½N	β Pegasus
2. ذنب قيطس Danab Qitas [Tail of Cetus, sea-monster]	5°	9°S	359°	21°S	β Ceti.
3. عين الثور 'Ain ath-thur [Eye of the Bull].	67°	8°N	63°	5° S	α Tauri (Aldabarān)
4. كف الخضيب Kaff at-Khaḍib [Blood-stained palm].	1°	58°N	329°	51°N	β Cassiopœi.
5. رجل اليسرى Rijl al-Yasari [Left-sided Foot (of Orion)].	75°	8°S	70°	32°½S	β Orionis Rigel
6. يد يمنى Yadd yamani [Right hand (of Orion)].	83°½	7°N	76°	18°S	α Orionis (Betelgeux)
7. شعره يمانى Sha'ari Yamāni [Sha-'ari of Yaman].	99°	15°S	101°	40°S	α Canis Major (sirius)
8. شعره شامى Sha'ari Shāmi [Sha-'arah of Sham (Syria)]	112°	6°N	114°	15°S	α Canis Minor (Procyone)
9. فردا لشجاع Farad al-Shujā'a [Solitary Warrior]	142°	7°S	142°	20°½S	α Hydra (Al-fard)
10. قلب الاسد Qalb al-Asad [Heart of Lion]	151°	11°N	149°	0°	α Leonis (Regulus)
11. ظهر الدبّ Ẓahr al-Dubba [Back of the Bear].	162°	54°N	131°	51°N	α Ursa Major
12. قاعده Qā'adah [Base (of the Cup)].	165°	18°S	170°	24°S	α Crater
13 جناح الغراب Janāḥ al-Ghurrāb [Wing of the Crow].	182°	16°S	182°	17°S	γ Corvus
14 سماك الاعزل Simāk al-A'azal [The exalted one in wilderness].	200°	10°S	200°	3°S	α Virgo (Spica)
15. سماك الرامح Simak al-Rāmaḥ [The exalted one with the spear].	213°	20°N	214°	30°N	α Bootes (Arcturus)
16. عنق الحيه 'Unaq al-Ḥayah [Neck of the Serpent].	236°	6°N	231°	25°N	α or λ Serpentis
17. نيّر فكه Naiyar Fakkah [Bright one of the Bowl].	237°	28°N	2°	45°N	α Corona Borealis (Alphecca)

Name	Right Ascension	Declination	Longitude	Latitude	Remarks
18 قلب العقرب Qalb al-'Aqarab [Heart of Scorpion].	245°	25°S	246°	3°S	α Scorpio (Antares)
19. راس الحوا Rās al-Hawwā [Head of Snake-chamer].	268°	14°N	266°	42°N	α Ophiuchus
20. النسرواقع An-nasra Wāqa'a [Swooping Vulture].	279°	40°N	276°	59°N	α Lyra (Vega)
21. النسرطاير An-nasra Tāyir [Soaring Vulture].	296°	7°N	298°	30°N	α Aquilla (Al-tair)
22. رديف Radif [Back-rider].	311°	44°N	306°	59°N	α Cygnus.
23. فم الفرس Fum al-Faras [Mouth of the Horse]	326	8°N	321°	23°N	γ or ε Pegasii
24. ساق يمانى Sāq Yamāni [Leg towards Yaman, right side leg].	344°	17°S	342°	9°S	γ Aquuarius

AL'IḌĀDAH (العضاده) *i. e.* the pointer, the dioptre, is on the face over the Ankabūt; over it is a small nut, called فلس (fals) used as a washer and through a slit on the pivot passes a wedge made like a horse فرس (Faras) at one end, which fixes the tablets, Ankabūt and Al'iḍādah.



THE WEDGE. (فرس fars = a horse)

Like Kaye A. O. J. S. Pl. VIII. Fig. 24 D.

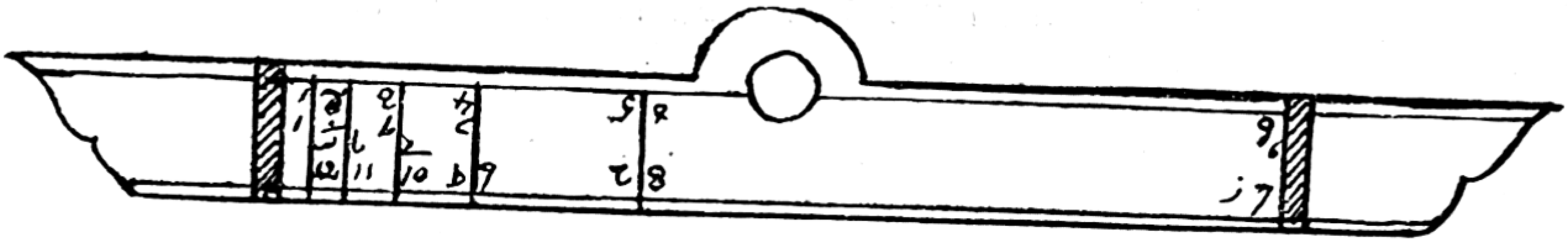
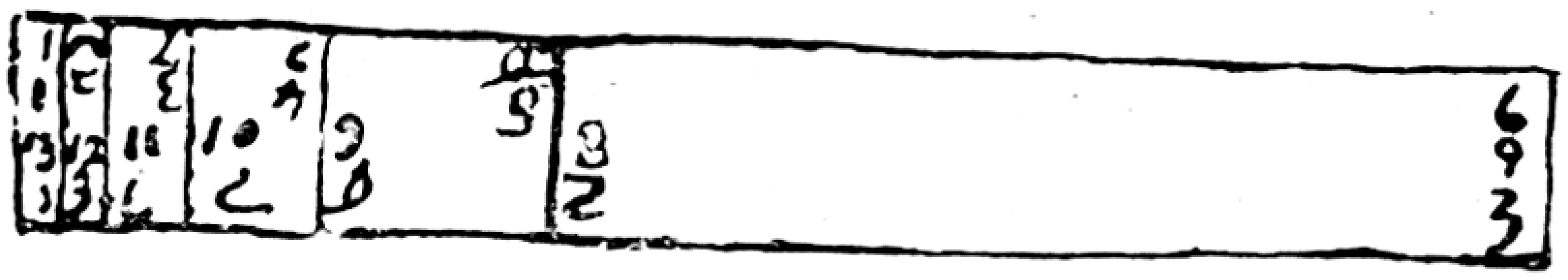


Fig. 15—The Al'idade (dioptre) of the MFL Astrolabe.

Length of Al'idāda from point to point is 115 Mm. It is not divided along the side into parts, but on its upper surface are marks showing tangent scales. Its breadth is 9.5 Mm.

The height of each tile (لبنه libana) is 11 Mm. Distance between is divided and marked thus :—



The distance of each dividing line from the left tile is respectively 2½, 5½, 9½, 15, 27, 75 Mm.

The Al'idāda can be fitted *both* on the back and front.
The Length of the pivot is 28 Mm., with a convex knob at one end.

[This completes the Description of the Astrolabe in the Mulla Feeroz Library, Bombay.]

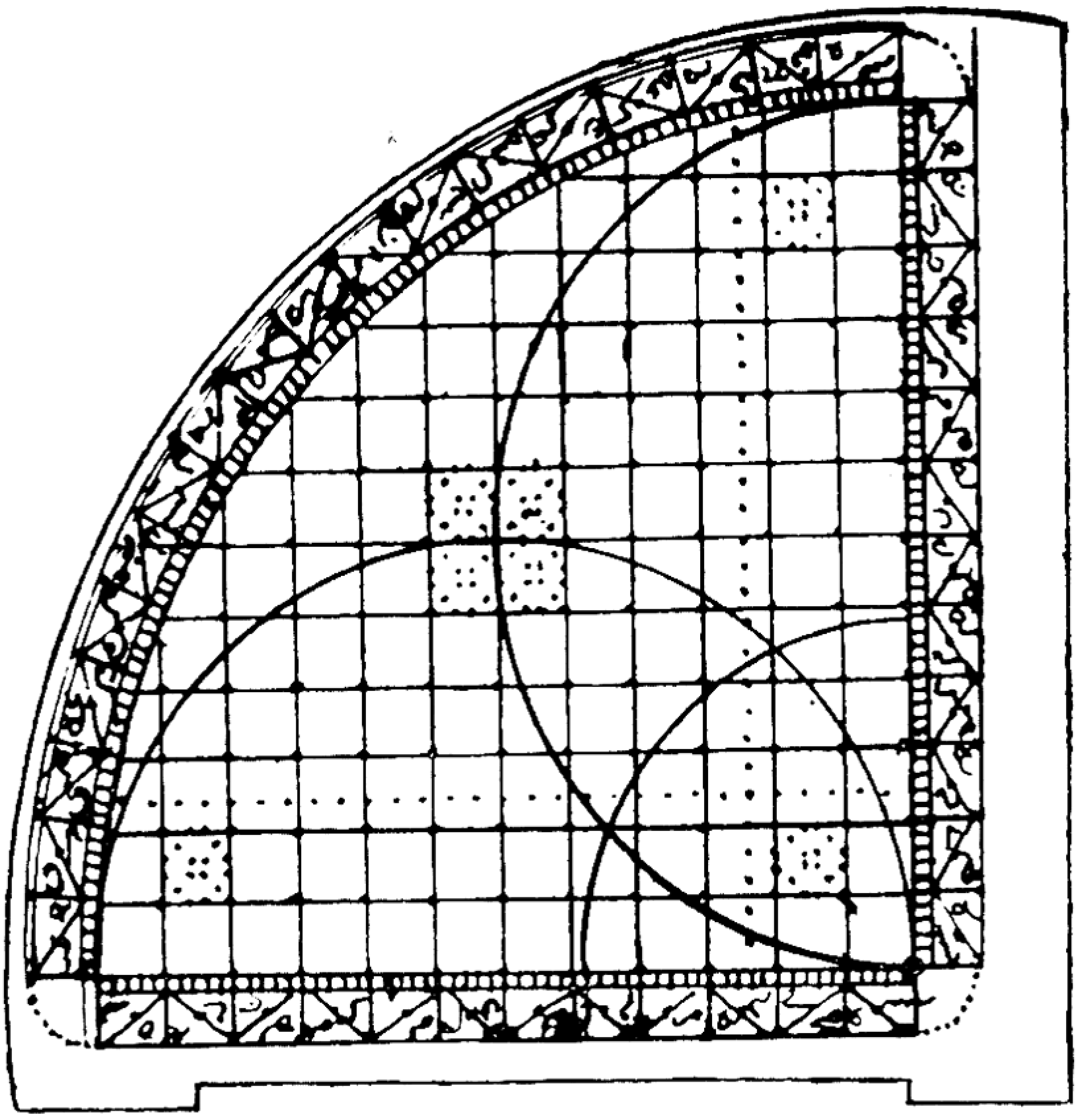


Fig. 16 The obverse of the wooden Quadrant in M. F. Library.

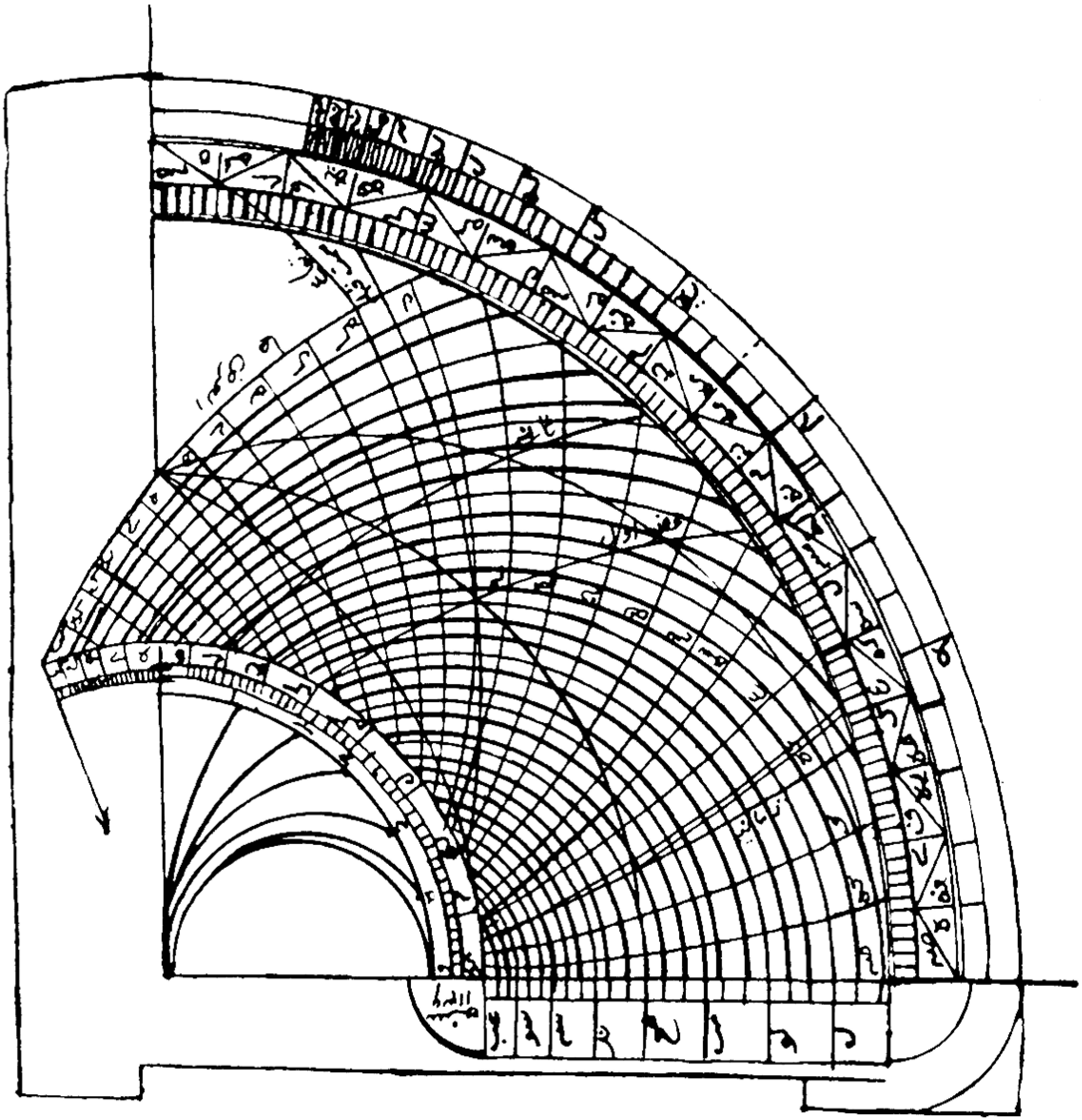


Fig. 17— The Reverse of the Wooden Quadrant in M. F. Library.

WOODEN QUADRANT IN THE MULLA FEEROZ LIBRARY, BOMBAY.

NOTE

[The wooden Quadrant in the Mulla Feeroz Library kept along with the Astrolabe previously described and whose description is given by Mr. Khareghat in the following pages, is worthy of special notice, not only because of its ingenious construction, but because of the exquisite and delicate *workmanship* of the Mechanic who conceived and prepared it. The lines which are drawn out and the numbers which are marked on it are in red and black colours, of which the red colour has now become faint and has nearly lost its brilliancy and therefore red could be seen with some difficulty. In course of time, it is just possible that the red may diminish further in intensity and the lines and figures may become troublesome to be noticed and read out. But the black colour is very clear and though nearly 222 years have elapsed since its construction, it is as clear as what one would wish it to be. The workmanship is exquisite and reflects great credit on the Artist who prepared it. Such thin lines are so well drawn that it is a delight to observe and appreciate the art.

This Quadrant, may in fact be considered a partial Pocket Astrolabe prepared for a place, of North Latitude 41°. Latitude of 41° is just in the neighbourhood of the present city of Samarqand, which was in old days so famous for its observatory, where astronomers like Mirza Ulugh-Beg, so assiduously worked and completed in A. D, 1436 his Astronomical Tables almost as famous as the Tables of Ptolemy and which formed the basis of subsequent catalogues. It is just possible that the Artist may be one interested in this place and prepared a nice pocket quadrant for his own use.

For a better appreciation of the description of the Quadrant as given in the following pages, sketches of the Front and the Reverse are drawn to scale (of course roughly) and numbered as fig. 16 and fig. 17. and it is hoped that the reader will be better enabled to gather sufficient information visually from them.

The Front gives the usual Sine and Cosine scales, as are generally found at the backs of Astrolabes. But both the horizontal and vertical lines are all accurately drawn and are equidistant. At all principal points of demarcation, on both the faces, fine pins of good brass (which still shine as gold) are inserted to render reading convenient and easy. These are indicated by dots in the figures. The Quadrantal Arc is graduated into degrees and all the 90 degrees are marked and groups of five are numbered in red from one end of the arc to the other and *vice versa* in black. The vertical and horizontal diameters are divided into twelve parts by black lines, and they are also divided into sixty parts, the remaining 48 lines being in red. These 48 red lines are not shown in fig. 16, to avoid overcrowding. At the centre of arc *i. e.* at the point of intersection of the vertical and horizontal diameters, a bigger brass pin, with a hole in the centre, is inserted so as to hold firmly the compass leg whilst drawing various circles.

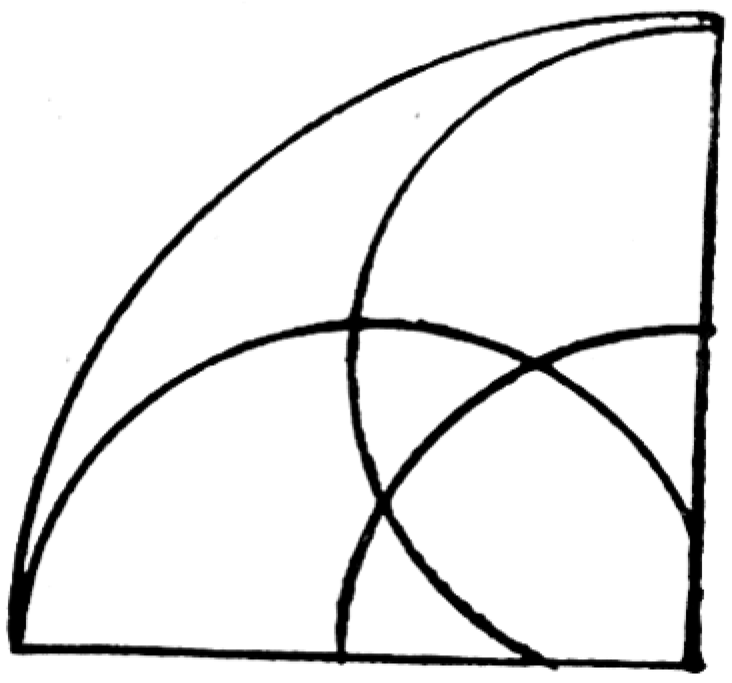
On the *Reverse* is drawn a fourth part of the Tablet or Disc Ṣafiḥah (صفیحه) usually given in Astrolabes for latitude 41° as per fig. 8, which exhibits the whole disc. The fourth part of the Tablet drawn on the Quadrant is indicated by thicker lines in fig. 8, of that Tablet. From fig. 17, all principal details as given on the Reverse side of the Quadrant and described by Mr. Khareghat can be easily appreciated. Mr. Khareghat even seems to have attempted to draw the figure for himself as may be guessed from the tabulated calculations, given by him in Note B appended hereunder; but for drawing the Muqanṭarāts (circles of altitude) further tables giving the positions of the centers of the circles (whose radii are obtained by calculation Tables in Note B) are required.

The year of manufacture of the Quadrant is given as A. H. 1136 *i. e.* A. D. 1723-24, and hence we cannot but appreciate and admire this exquisite piece of workmanship, and compliment the Artist for exhibition of such skill in craftsmanship some 222 years ago].

DESCRIPTION OF THE WOODEN QUADRANT, IN THE SAME BOX ALONG WITH THE ASTROLABE.

Quadrant of yellowish wood. Well varnished and shining. Its external radius is 93 Mm.; on one side there is a slip cut out 68.5 x 3.5 Mm.

On one face of this quadrant is marked a sine scale consisting of a quadrant 78 Mm. in radius. The two perpendicular radii forming the quadrant divided into 60 equal parts and parallels are drawn to the other radius from each of these dividing points, thus dividing the quadrant into a number of equal squares ; the line marking each 5th division is black, whereas that marking each of the other divisions is red; each group of 5 divisions are numered ه (5), ى (10), يه (15), etc. upto س (60) in black from the centre to the circumference, and in red from the circumference to the centre. The circumference is divided into 90°, every group of 5° being numbered ه (5), ى (10) etc. upto ص (90); the numbers from the bottom being in black ink and from the top in red. Further, 3 parts of circles are drawn in the quadrant ; in a semi-circle standing on each of the radii, the radius of each such being 30 parts; a quadrant is also drawn with the same centre as the main quadrant but with a radius of 24 parts. Thus the whole figure is roughly



This may be compared with the upper right quadrant of Kaye D. M. A. I. Fig. 4.

THE OTHER FACE:

The part with the notch may be called the horizontal side and that perpendicular, the vertical. This has also a big quadrant, the centre of which is 14 Mm. from the left side and radius 74 Mm. Concentric with this is a smaller quadrant 28 Mm. radius, which is extended for 22° beyond the perpendicular, thus forming an arc of 112°. Within this smaller quadrant is drawn one in red with a radius of 26 Mm. In this are drawn arcs in red ink for hours exactly as in Kaye D. M. A. I. Fig. 4, left upper quadrant—the semicircle in this case resting on the horizontal radius; the hours are marked near the circumference beginning with ا near the top, at about 15° from the top and ending with و (6) at the bottom, all the arcs being of 15° each. Just below the place where the 6 hour line ends is the date سنه ١١٣٦ *i. e.* year 1136. The circumference of the main quadrant is divided into degrees and numbered for every 5° in black from above and in red from below. The interior of the quadrant seems divided into Muqanṭarats and Azimuth lines. The degrees of altitude for the Muqanṭarats seem marked in red along the horizontal radius. For 26, 30, 36, 42, 48, 54, 60, 66, 72 degrees of altitude, the distances from the centre are respectively 73, 68, 61, 54½, 49½, 44½, 40, 36, 32 Mm.; between the altitude circles from 30° to 72° which are drawn in black are others for every 2° interval and drawn in red. The Azimuth line for 90° (ص) coincides with the horizontal radius; other Azimuth lines are marked for every 15° in black, viz. 75°, 60°, 45°, 30°, 15°, and 0°; the last one terminates on the perpendicular line 48.5 Mm. from the centre; they are further extended to the left upto the smaller quadrant, there being such Azimuth lines for 15° and 30°; between these Azimuth lines in black there are others in red for every 5° which are numbered. Outside the Muqanṭara circle which would correspond to 0° (*i. e.* the horizon) are written the words الارض اه (altitude 0°)- One azimuth line drawn in red between that for 25° and 30°, probably near 27, is marked just outside the horizon : ارتفاع سمت قبله

[Parallel to the quadrantal circles, marking the graduations from 0° to 90° in red and from 90° to 0° in black, there are two concentric circles graduated in black, in divisions from 0° to 60° (سه ، نه , ن , مه , م , له , لـ ، كه , ك , يه , ے ، ه) the abjad figures being in red ; and these divisions are obviously unequal and represent, what has already been described in previous sections (ẓill-i-aṣabi'a) ظل اصابع the shadows in fingers or digits for a gnomon divided into 12 parts; (vide pp. 8, 9.) and also tangents of corresponding angles marked on the quadrants, each multiplied by 12: thus—we have—

$\tan 5^\circ = 0.0875$	and these values each	$= 1.0500$	which are the
$\tan 10^\circ = 0.1763$	multiplied by 12, are	$= 2.1156$	values to be
$\tan 15^\circ = 0.2679$		$= 3.2148$	noted just at
$\tan 20^\circ = 0.3640$		$= 4.3680$	the angles,
$\tan 25^\circ = 0.4663$		$= 5.5956$	marked on
$\tan 30^\circ = 0.5774$		$= 6.9288$	the Quadrant.
$\tan 35^\circ = 0.7002$		$= 8.4024$	
$\tan 40^\circ = 0.8391$		$= 10.0782$	
$\tan 45^\circ = 1$		$= 12$	
$\tan 50^\circ = 1.1918$		$= 14.3016$	
$\tan 55^\circ = 1.4281$		$= 17.1372$	
$\tan 60^\circ = 1.7321$		$= 20.7852$	
$\tan 65^\circ = 2.1445$		$= 25.7340$	
$\tan 70^\circ = 2.7475$		$= 32.9700$	
$\tan 75^\circ = 3.7321$		$= 44.7852$	
$\tan 78^\circ 36' = 5$		$= 60.002.$	

enabling one to find the tangents of angles upto 78° 36′

NOTES

A.

Angles	Value of Tangents	Values of Tangents reduced to the scale of 11, as one unit *i. e.* multiplying by 11.
15°	0.2679492	2.948
30°	0.5773503	6.347
45°	1.0000000	11.000
60°	1.7320508	19.052
75°	3.7320508	41.052

[vide p. 4 Note]

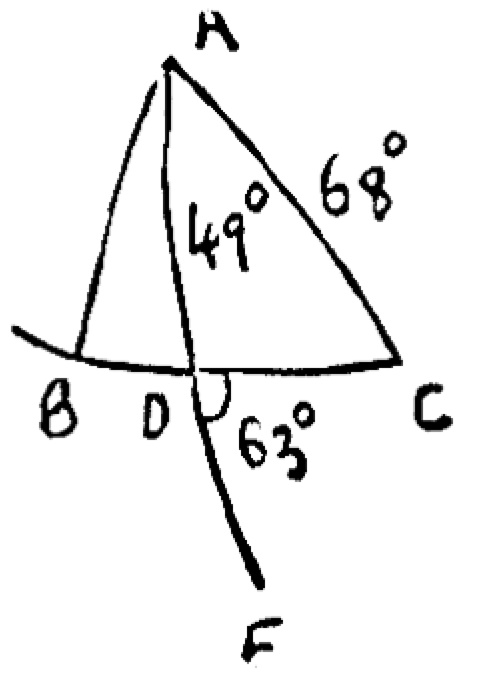
B. Calculation Tables for the the Muqanṭarāts at a place 41°, N. Latitude = 49° Polar Distance

		Angles	Tangents	With equatorial radius 49 mm.		With equatorial radius 48.5
	$\frac{1}{2}$ of 49	$24^\circ\frac{1}{2}$	.456	22.344		22.12
72°	$\frac{1}{2}\{49+18\}$	$33^\circ\frac{1}{2}$	.662	32.4		32.2
66°	$\frac{1}{2}\{49+24\}$	$36^\circ\frac{1}{2}$	.740	36.3		36.0
60°	$\frac{1}{2}\{49+30\}$	$39^\circ\frac{1}{2}$	.824	40.4		40.0
54°	$\frac{1}{2}\{49+36\}$	$42^\circ\frac{1}{2}$	.916	44.9		44.5
48°	$\frac{1}{2}\{49+42\}$	$45^\circ\frac{1}{2}$	1.018	49.7		49.2
42°	$\frac{1}{2}\{49+48\}$	$48^\circ\frac{1}{2}$	1.130	55.4		54.9
36°	$\frac{1}{2}\{49+54\}$	$51^\circ\frac{1}{2}$	1.257	61.4		60.8
30°	$\frac{1}{2}\{49+60\}$	$53^\circ\frac{1}{2}$	1.402	68.6		67.9
26°	$\frac{1}{2}\{49+64\}$	$56^\circ\frac{1}{2}$	1.511	74.0		73.3
24°	$\frac{1}{2}\{49+66\}$	$57^\circ\frac{1}{2}$	1.570	76.9		76.2
Horizon 0°	$\frac{1}{2}\{90+49\}$	$69^\circ\frac{1}{2}$	2.675	131.1	Rad 74.7 of Earth Dist. from centre 56.4	74.0
0°	$\frac{1}{2}\{90-49\}$	$20^\circ\frac{1}{2}$	.374	18.3		55.8
Tropic of Cancer	$\frac{1}{2}\{66\}$	33	.649	31.8		31.5
Tropic of Capricorn	$\frac{1}{2}\{114\}$	57	1.540	75.5		74.7

These tables enable one to draw muqanṭarāts for a place of Lat. 41° N.

C. The Trigonometrical problem of finding from the known orientation of Mecca, the longitude of a place of given latitude and *vice versa* is attempted as under :—

Problem (1) If D be a place of known latitude 41° N, C the position of Mecca (lat. 22° N), and $E\hat{D}C$ = 63° = orientation of Mecca, to find DAC (Difference of Longitude of the two places).



[The distance DC, between the two places is called, *masāfat* (مسافة), the angle EDC, the angle of orientation is called *jihat* (جہت), and the angle DAC, the difference in longitude of the two places is called inḥirāf (انحراف)].

$$\begin{array}{rl} L \sin 49^\circ = & 9.8777799 \\ +L \sin 63^\circ = & 9.9498809 \\ \hline & 19.8276608 \\ \text{less } L \sin 68^\circ = & 9.9671659 \\ \hline & 9.8604949 \end{array}$$

$\therefore L \sin C = L \sin 46^\circ\ 29'$

or $C = 46^\circ\ 29'$

$$\begin{array}{rl} L \cos 68^\circ = & 9.5735754 \\ +L \tan C = & 10.0224970 \\ \hline = & 19.5960724 \\ = & L \cot BAC + 10 \\ = & L \cot 68^\circ\ 28' + 10 \end{array}$$

$\therefore BAC = 68^\circ\ 28'$

$$\begin{array}{rl} L \cos 49^\circ = & 9.8169429 \\ L \tan 63^\circ = & 10.2928341 \\ \hline & 20.1097770 \\ = & L \cot B\hat{A}D + 10 \\ = & L \cot 37^\circ\ 46' + 10 \end{array}$$

$\therefore B\hat{A}D = 37^\circ\ 46'$

Hence, $D\hat{A}C = 68^\circ\ 28' - 37^\circ\ 46'$

$= 30^\circ\ 42'$

PROBLEM (2) If EDC is 27°—

$$\begin{array}{rl} L \sin 49^\circ = & 9.8777799 \\ +L \sin 27^\circ = & 9.6570468 \\ \hline & 19.5348267 \\ \text{Less } L \sin 68^\circ = & 9.9671659 \\ \hline & 9.5676608 \end{array}$$

$= L \sin C$

$= L \sin 21^\circ\ 41'$

$\therefore\ C = 21^\circ\ 41'$

$$\begin{array}{rl} L \cos 68^\circ = & 9.5735754 \\ +L \tan C = & 9.5994588 \\ \hline & 19.1730342 \\ = & L \cot BAC + 10 \\ = & L \cot 81^\circ 32' + 10 \end{array}$$

$B\hat{A}C = 81^\circ\ 32'$

$$\begin{array}{rl} L \cos 49^\circ = & 9.8169429 \\ +L \tan 27^\circ = & 9.7071659 \\ \hline & 19.5241088 \\ = & L \cot B\hat{A}D + 10 \end{array}$$

$B\hat{A}D = 71^\circ\ 31'$

Hence $D\hat{A}C = B\hat{A}C - B\hat{A}D$

$= 81^\circ\ 32' - 71^\circ\ 31' = 10^\circ 1'$

NOTES FROM THE JOURNAL ASIATIQUE 1893
(Series 9, Vol. I).

Sur une mère d'astrolabe Arabe du XIIIe siècle (609 de l'Hégire) portent un Calendrier Perpétuel avec correspondance Musulmane et Chrétienne. Traduction ét interprétation par M. H. Sauvaire, correspondant de l'Institut, et M.J. De Rey Pailhade ingenieur civil des mines.

Pages 5 to 76 and 185-231.

PART I, p. 5-76.

(P. 5) Acquired at Cairo in 1873 by M. Sauvaire. Of copper and bears traces of gilding. Wt. 300 Gramme. Diameter 165 Mm. inclusive of the limbe (rim), which is 6 Mm. The rim is fixed to the face of the "mother" by 14 small iron nails.

(P. 6) On sait que la *mère* d'un astrolabe (أمّ الاصطرلاب umm al-aṣṭarlāb) est la piece fondementale (اصل aṣl)[1]

Elle comprend : la face (وجه wadjah), le dos (ظهر ẓahr), le limbe (حجرة ḥedjarat). L'anneau de suspension (حلقة ḥalqah) et l'anse (handle) (عروة 'irwat) ou ganse (bobbin) (عروه 'urwah) a laquelle tient l'anneau. Cette anse ou etrier (stirrup) est rattachee a l'instrument par un petit clou, rivé et mobile qui le traverse de part en part. L'appendice dans lequel pénètre ce clou s'appelle le *siège* (كرسی Kursi). Au centre de la *mère* est pratiqué un petit trou rond appelé (المحن l'almeḥan), destiné à contenir l'axe (القطب al-quṭb) qui maintient, reliées ensemble, les différentes safiḥah (صفيحه) ou disques, *l'araignée* (العنكبوت al-'ankabūt) et l'alidāde (العضاده)[2]. Le trou carré dans lequel s'engageaient les languettes des ṣafiḥah est creusé tout au haut de la' mère sous le limbe.

The rim is divided into 360°, separes de cinq en cinq, and indicated below by letters. All numbers save 60 are indicated by letters.[3]

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[1] Ms. suppl. ar. de la Bibl. nat. 961 bis, fol. 69 v°).

[2] *Cf.* sur tous ces termes le Mémoire sur les instruments astronomique des Arabes, par L. Am. Sédillot, et, entre manuscrits arabes, le n° 612 ancien fonds et le n° 691 bis supplément de la Bibliotheque nationale.

[3] The Arabs have borrowed from the Greeks this manner of representing numbers by letters.

Order called Aboudjad. Il existe deux aboudjad : (1) l' oriental et (2) l'occidental.

(P. 7) The author has used the second method in engraving this instrument at Seville, viz.

صعفض	كلمن	حطى	هوز	ابجد
D, F, ‘a, *S*	N, M, L, K,	Y, Ṭ, *H*	Z, W, H,	D, Dj, B, A
90, 80, 70, 60	50, 40, 30, 20	10, 9, 8	7, 6, 5	4, 3, 2, 1

ظغش	ثخذ	قرست
Ch, Gh, *Z*	Ḍ, Kh Th	T, S, R, Q
1000, 900, 800	700, 600, 500	400, 300, 200, 100

Still the engraver has replaced ش (1000) by ا (A), in the numbers, ان =1050, ارص = 1260, et ات =1400.[1]

[vide preface p. ix]

The characters are ornamental Cufic occidental. Below the pin which holds the handle on the "back" (P. 8) is the word روبيه [a piece of wood with which a breach in a wooden bowl is stopped up; vide Lane 1176.] the sense of which is unknown to me, and below that صنعه محمد بن فتوح الخمايرى "Mohammad ebn Fatouḥ el Khamairy l'a construit[2]."

On the "face", entre les festons de rebord supérieur and 20° du haut du limbe are the words : بمدينته اشبيليته فى سنته خط *i. e.* Dans la ville de Séville, en l'année 609[3].

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[1] In the original according to the occidental method the F has the nukhta (point) below ڢ and the Q one nukhta above ف

[2] صنع indicates the manual art of making. In Persia the Astronomers themselves made the astrolabes. (Chardin, tome III. p. 168). But I believe Md. ibn Fatouḥ was only the engraver ; his name is also inscribed on the tablet spoken of by M. Jomard.)

[3] On a tablet of Arzachel (Abou Isḥaq Ibrahim ebn Yahya en-Naqqāih) acquired by M. Jomard for the Bibl. royale which was a part of the Scultz collection there is, according to M. Sédillot, the inscription:

صنع هاذه الصفيحته محمد بن فتوح الخمايرى بمدينته اشبيليته عمرها الله فى سنته خيه الهجرته

"Cette ṣafiḥah a été construite par Mohammad ebn Fatoûh el Khamāïry dans la ville de Séville, que Dieu la rende florissante! en l'année 615 de l'hégire." Another tablet made by him at Seville in 613 is with M.A. da Schio (Voir Atti del IV Congresso internazionale degli Orientalisti, Firenze. 1880. p. 368.

(P. 9). A. H. 609 began on Saturday 2nd June 1212, v. st. (vieux style). The letters showing the degrees on the rim readable from outside, from O at the top proceeding in the same direction as the hands of a watch ↻ from and after 115, the letter for the hundred is not marked on the odd degrees.

(P. 10). La partie concave est sans contredit la plus intéressante de la face de l'astrolabe auquel notre *mère* appartenait. C'est un instrument peut-étre unique, tout au moins inédit, de chronologie musulmane et de concordance entre les années de l'hégire et juliennes. Elle contient treize (13) cercles concentriques, soit douze (12) zones circulaires dans lesquelles sont inscrits des mots ou des lettres tantôt isolées, tantôt accouplées. Nous désignerons ces zones par les chiffres (figures) romains de I a XII, en allant du centre a la périphérie.

(P. 11) Les cercles, linéairs, sont doubles ou simples. Sont doubles: 1st, 2nd, 4th, 5th, 7th, 10th, and 13th; simples: 3rd, 6th, 8th, 9th, 11th and 12th. The words are separated by radii or parts of radius (ou des parties de rayon). Quatre rayons, egalement espaces, divisent tous les cercles en quatre quarts.

Les légendes des zones doivent se lire de droite à gauche, mais quelques-unes en tenant l'instrument renversé. Nous les reproduirons sous forme de colonnes, portant en téte le chiffre romain.

Dans le petit cercle central, an lit sous ری (RY = 210): عربی *araby*, "arabe", et en renversant l'instrument, au-dessus de کح (K̲H = 28); عجمی 'Adjamy', "non arabe, barbarus des Latins, étranger, persan et *ici* chrétien[1]."

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[1] On lit dans le So'oud el Matâlé, p. 261: "L'ère des Grecs (الروم) et des Persans (الفرس) est basée sur ce que l'annèe se compose de 365 jours et un quart de jour, ni plus ni moins. Ensuite les Romains (الرومان) adopterent pour quatre mois; *techrin el akher*, *nisan*, *hozayrân* et *ayloûl*, 30 jours; pour sept mois: *techrin el awal*, les deux *kanoun*, *adar*, *ayar*, *tammouz* et *âb*, 31 jours; et pour un mois, celui de *chobat*, 28 jours pendant trois années consécutives et 29 dans la quatrième année, qui est la bissextile. Car lorsqu'ils prirent les mois de la manière indiquée ci-dessus, ils obtinrent 365 jours et il resta un quart de jour qui, tous les quatre ans, forma un jour. En conséquence, ils l'ajouterent à la fin de février particulièrment, vu que, bien qu'il ne fut pas le dernier de leurs mois, c'etait celui qui avait le plus petit nombre de jours.

(P. 12) Description of the zones beginning with those near the centre and going to the circumference.

1st ZÔNE BETWEEN THE 1st AND 2nd DOUBLE CIRCLES:

ری	RY	210	Z̲M	ظم	840
تك	TK	420	AN	ان	1050
خل	KhL	630	ARS	ارص	1260

I (bis)

Reading inwards to left from top.		Reading outwards to right from top (or reversing the instrument to left).	
كح	28	رف	280
نو	56	تك	420
فد	84	تنص	560
قيب	112	ذ	700
قم	140	ات	1400

Redressons l'instrument et commencons la lecture à la gauche du rayon de droite. Les trois zones II, III et IV forment un ensemble.

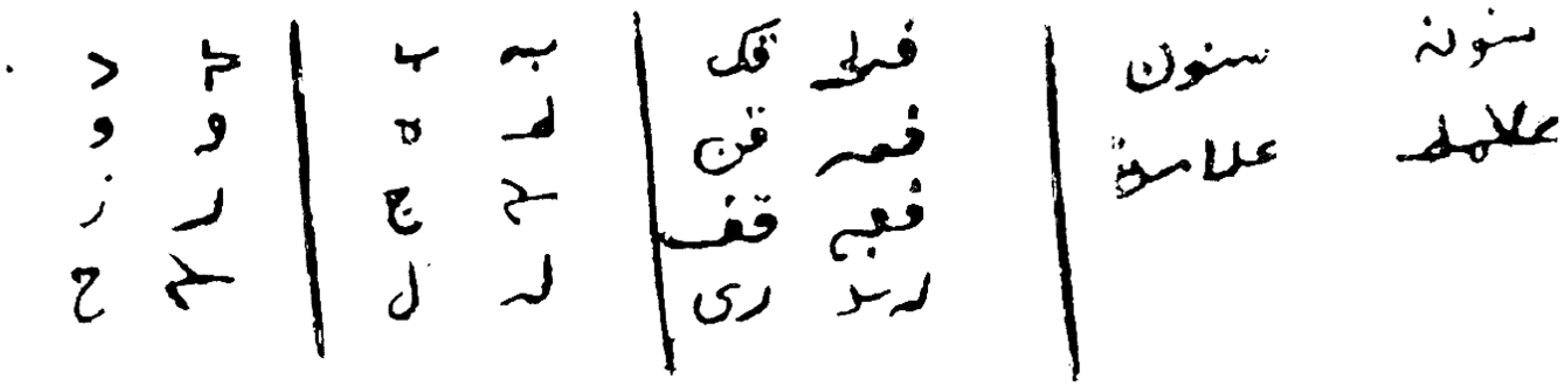
II			III			IV		
كبايس	Kabāis	Bissex-tiles.	علامه	'alāmah	signe	سنون	sanoun.	Années
ك	K	B	د	D	4	ا	A	1
			ا	A	1	ب	B	2
			و	W	6	ج	Dj	3
ك	K	B	ج	Dj	3	د	D	4
			ز	Z	7	ه	H	5
			ه	H	5	و	W	6
ك	K	B	ب	B	2	ز	Z	7
			و	W	6	ح	H̲	8

(p. 13) Renversons l'instrument et commencons la lecture à la droite du même rayon que ci-dessus. Les trois zone II *bis*, III *bis* et IV *bis* forment également un ensemble. Le commencement des deux premieres est traversé par le mot علامه 'alāmah, signe.

Les Maghrébins et les Francs font usage de cette ère, mais avec d'autres mois, dont les noms et le commencement different seuls de ceux-là. Et ils les appellent 'adjamyeḥ (pluriel de 'adjamy). Quelques-uns d'entre les Francs datent leur ère de la naissance du Messie, laquelle est postérieure au commencement de l'ère dont il est question plus haut.

II bis	III bis			IV bis.		
ب B C¹	ه	H	5	ل	L	30
repeated 7 times	ج	Dj	3	ص	S̲	60
(¹Note: De même que,	ا	A	1	ض	D̲	90
plus haut, j'ai employe	و	W	6	قك	QK	120
le B, prémiere lettre du	د	D	4	قن	QN	150
mot "bissextile", je me sers ici du C, initiale	ب	B	2	قف	QF	180
du mot "commune".	ز	Z	7	ری	RY	210

Letters and words in Cufic characters:—



ZONES V & VI Zones V and VI are separated from each other by a single circle and from those before and after by a double circle. Zone VI contains the names of the Mohammedan months and Zone V. corresponding numbers, viz.

Moharam,	ا (1)
Safar,	ج (3)
Rabî' I.,	د (4)
Rabî' II.,	و (6)
Djoûmâda I,	ز (7)
Djoûmâda II.,	ب (2)
Radjab,	ج (3)
Cha'bān	ه (5)
Ramadân,	و (6)
Chawwâl,	ا (1)
القعده El Qa'dah,	ب (2)
الحجه El Hadjah.	د (4)

Both the Zones commence from the vertical radius and go left reading inwards.

ZONES V and VI Bis. Read outwards and commence from the vertical circle and go right. Zone VI contains the names of the Christian months without vowel points and hence not transliterated; Zone V Bis contains the corresponding numbers.

ينير	فبرير	مارس	ابريل	مايه	يونيه ه
ا (1)	د (4)	ذ (4)	ز (7)	ب (2)	ه (5)
يوليه	اغشت	شتنبر	اكتوبر	نونبر	دجنبر
ز (7)	ج (3)	و (6)	ا (1)	د (4)	و (6)

(P.15) ZONES VII., VIII., and IX are separated from each other by single circles and form those before and after by double circles.

(P. 16) They begin to the left of the vertical radius (rayon superiéur)

VII		ك B[1]				ك B				ك B				ك B
VIII	و (6)	ز (7)	ب (2)[2]	ج (3)	د (4)	ه (5)	و (6)	ا (1)	ب (2)	ج (3)	د (4)	و (6)	ز (7)	ا (1)
IX	ا (1)	ب (2)	ج (3)	د (4)	ه (5)	و (6)	ز (7)	ح (8)	ط (9)	ى (10)	يا (11)	يب (12)	يج (13)	يد (14)
VII				ك B				ك B				ك B		
VIII	ب (2)	د (4)	ه (5)	و (6)	ز (7)	ب (2)	ج (3)	د (4)	ه (5)	ز (7)	ا (1)	ب (2)	ج (3)	ه (5)
IX	يه (15)	يو (16)	يز (17)	يح (18)	يط (19)	ك (20)	كا (21)	كب (22)	كج (23)	كد (24)	كه (25)	كو (26)	كز (27)	كح (28)

NOTE 1 at P. 15. (Although K has the value 20, here it is the initial of Kabisa or "bissextile". C'est donné par inadvertance que M.Sedillot (Loco cit., P. 175) ne lui a pas donné ce sens. Ce savant, en nous decrivant la *mère* de l'astrolabe de M. le barron Larrey construit en 615 (1218 de J.C.) dans la ville de Maroc par Abou Bakr ebn Yousef, s'exprime ainsi, mais sans donner aucune explication : "Il y a de plus trois cercles concentriques divisê en 28 parties: le premier contient l'indication des nombres 1 à 28; le second, les nombres 1 à 7 disposes de la manière suivante : 1, 2, 3, 4, 6, 7, 1, 2, 4, 5, 6, 7, 2, 3, 4, 5, 7, 1, 2, 3, 5, 6, 7, 1, 3, 4, 5, 6; ce qui donne quatre series de 7; les nombres manquants etant 1, 3, 5, 7, 2, 4, 6; (there is a mistake here–M.P.K.) enfin, le troisieme cercle comprend le *nombre* 20 répeté sept fois sous les nombres 1, 3,

(P.16). Les trois dernières zones (X. XI et XII) constituent un tout ; elles sont placées enter deux cercles doubles et séparées l'une de l' autre par un cercle simple.

(P. 17) X المتجاوزه Qui si dèpassent (excédantes).
XI المتفقه الاصل Dont l' origine concorde (égales).
XII ايام Jours. 60^3 60.

X	ا 1	ب 2.	ج 3.	د 4.	ه 5.	و 6.	ز 7	ح 8	ط 9.	ى 10	يا 11
XI	يط 19	نج 53	فو 86	قك 120	قند 154	قفز 187	ركا 221	رند 254	رفح 288	سكا 321	سنه 355
XII	ب 2	ز 7	ا 1	ه 5	ى 10	د 4	ط 9	ج 3	ح 8	ب 2	و 6
X	يب 12	يج 13	يد 14	يه 15	يو 16	يز 17	يح 18	يط 19	ك 20	كا 21	
XI	سفط 389	تكب 422	تنو 456	تفط 489	شكج 528	ثنو 556	[4] ثض 590	خكج 623	خنز 657	خضا 691	
XII	يا 11	ه 5	ى 10	د 4	ط 9	ج 3	ز 7	ا 1	ه 5	يا 11	

5, 7, 2, 4, 6," .. Il est facile de reconnaitre dans ces trois cercles concentriques les zones que nous designons sous les n^os VII, VIII et IX, avec cette difference que le cercle de l'astrolabe Larrey correspondant a notre zone VII commence avec la 8^e année du cycle du notre, continue ensuite jusqu'à la 28^e et reprend depuis la I^ere jusqu'à la 7^e année inclusivement dudit cycle. Il est a remarquer en outre que le graveur n'a pas commis l'erreur de ب (B = 2) pour ا (A = l)).

NOTE 2. (P. 15). Le ب (B) est une erreur de graveur ; il fallait ici un ا (A).—Abou'l Hasan de Maroc sa plaignait de ce que les constructeurs d'instruments de son temps ne savaient ni calcul, ni géométrie, prétendant que leur art pouvait se passer des notions théoriques).

NOTE 3. Le nomber 60 est exprimé en chiffers dits *ghobâr*. Cf. le *Memoire sur la propagation des chiffres indiens*, par M. F. Wōēpke, dans le Journal Asiatique, année 1863. L'auteur dit (p. 31) que ces chiffres employés par les Arabes occidenteaux sont tres semblables aux chiffres les plus anciens que l' on trouve dans les manuscrits du moyen age.) p. 17.

Note : 4. Le graveur a mis pas erreur un point sur le trait final du ض, ce qui donnerait ṮDZ = 597) p. 17

(P. 18)

X	کب 22	کج 23	کد 24	که 25	کو 26	کز 27	کح 28	کط 29	کی 30
XI	ذ کد 724	د نح 758	ذ ضا 791	ظکه 825	ظنح 858	ظفب 892	غکو 926	غنط 959	غضج 993
XII	ه 5	ط 9	ج 3	ح 8	ب 2	و 6	ب 12	و 6	ی 10

DOS DE L'ASTROLABE.[1]

We return to astronomy and leave Chronology.

Autour d'un double cercle central gradué, ayant intérieurement 93 millimetres de diametre, sont tracés six autres cercles concentriques: le première est linéaire et double, le deuxième est divisé en parties qui correspondent aux jours dont chaque mois se compose; le troisième et le quatrième sont linéaires simples; le cinquième est double et gradué et le sixième et dernier est linéaire double. Toutefois sur ce dernier s'appuie intérieurement, dans la moitié inférieure du dos, une partie de cercle gradué, dont l'usage sera indiqué plus loin.

(P. 19). Ces cercles forment six zones contenant des lettres-nombres, les mois de l'année julienne et les signes du zodiaque.

Les 360 degres du double cercle central sont indiqués de 5 en 5 dans la zone immédiatement supérieure par les lettres suivantes. *From* ه *5 to* ض *90.* Ce groupe se reproduit quatre fois: 1° dans le premier et 2° dans le second quart de gauche en allant de bas en haut: 3° dans le premier et 4° dans le second quart de droite, en lisant de bas en haut après avoir renversé l'instrument. Les quatre groupes réunis forment 360 degrés.

Les lettres dont il vient d'être question et qui sont séparées entre elles par des traits, comme celles dont nous allons parler, sont entourées d'un double cercle fin en dessus duquel sont gravées des lettres qu'enveloppe un double cercle contenant autant de séparations qu'il y a de jours dans le mois julien inscrit par-dessus. Ainsi, en tenant l'instrument (P. 20) renversé et en commencant un peu à gauche, soit a la hauteur du 19^e^ degre du quart intérieur de droite, on lit:

(Note: 1. Comp. Sédillot, loco. cit., p. 69 et suiv., et pl. XV, fig. 53. Le notre présente de notables différences).

يونيه	مايه	ابريل	مارس	فبرير	ينير
ه ى يه ك كه ل	ه ى يه ك كه لا	ه ى يه ك كه ل	ه ى يه ك كه لا	ه ى يه ك كه كح	ه ى يه ك كه لا
دجنبر	نونبر	اكتوبر	ستنبر	آغشت	يوليه
ه ى يه ك كه لا	ه ى يه ك كه ل	ه ى يه ك كه لا	ه ى يه ك كه لا	ه ى يه ك كه لا	ه ى يه ك كه لا

La zone qui vient immédiatement par-dessus renferme les noms des douze signes du zodiaque. Chaque nom est séparé du suivant par un trait vertical. Le trait placé à droite, c'est-à-dire au commencement du Belier الحمل tomberait à peu près, s'il était prolongé, sur le milieu du 14^e jour de mars, et le trait placé à sa gauche, vers le commencement du 14^e jour d'avril. Les autres signes continuent vers la gauche, dans l'order suivant:

الثور	الجوزا	السرطان	الاسد	السنبله
Le Taureau.	Les Géineaux.	L'Ecrevisse.	Le Lion.	L'Epi

الميزان	العقرب	القوس
La Balance	Le Scorpion.	L'Arc (Le Sagittaire)
الجدى	الدلو	الحوت
Le Capricorne.	Le Seau (le Verseau).	Les Poissons.

Par-dessus les signes du zodiaque, une zone contient les degrés de chacun d'eux, de 5 en 5, jusqu'à 30: ه ى يه ك كه ل et un double cercle, qui l'entoure, est divisé par des traits en 360 degres.

La sixième et dernière zone est partagée en deux moitiés, supérieure et inférieure. La supérieure est à son tour divisée en deux nouvelles moitiés qui, commençant l'une à droite et l'autre à gauche, pour aboutir au sommet, contiennent chacune les lettres nombres depuis ه (H) jusqu'a ض (D), c'est-à-dire les nombres, de 5 en 5, depuis 5 jusqu'à 90.

La moitié inférieure est divisée en deux séries identiques de lettres: l'une allant de droite à gauche, en remontant vers la gauche; l'autre se lisant (P. 22) également de droite à gauche, à la condition de tenir l'anneau en bas. Ces lettres sont séparées par des traits et entourées d'un double demi-cercle divisé en autant de degrés qu'en indiquent les différences entre la valeur numérique d'une lettre et celle de la lettre suivante. Ces letters sont :

ب	د	و	ح	ى	يب	يه	يح	كا	كد	كح	لب	لو	مب	مح
2	4	6	8	10	12	15	18	21	24	28	32	36	42	48.

Un espace d'environ 19 millimetres reste vide entre les letters مح (MH=48) et la moitié supérieure du dos de l'astrolabe. La surface circonscrite par le cercle interne est partagé en deux parties égales. La moitié supérieure contient des petits carrés formés par les lignes verticales qui se prolongent. dans la moitié intérieure et par des lignes horizontales. Il s'y trouve en outre un demi-cercle de 18 millimetres et demi de rayon, ayant pour centre le trou *almehan* المحن et reposant sur la ligne de séparation.

Dans la moitié inférieure, neuf demi-ellipses différentes coupent les lignes verticales dont nous venons de parler.

Quatre series identiques de lettres partent du trou central et se dirigent en haut, en bas, à droite et à (p. 23) gauche, se coupant à angle droit. Ce sont les suivantes :

و	يب	يح	كد	ل	لو	مب	مح	ند	ص
6	12	18	24	30	36	42	48	54	60

Le lecteur complétera facilement les description qui precèdent à l'aide des deux photographies ci-contre reproduisant la *mère* et *dos* de l'astrolabe.

Je passe la plume à mon savant collaborateur qui va nous fournir l'explication détaillée des lettres et légendes dont je n'ai fait que donner la lecture.

(*Short description in English by me*).

The Interior (*vide fig. 18*): The horizontal radii are each divided into 60 equal parts, and so is the vertical radius, and the parts are marked 6 to 60 from centre to circumference; but the lines are drawn for every 2 parts, so that there are in the upper semicircle 30 horizontal lines and 30 vertical. The 30 vertical lines are prolonged in the lower semicircle; the lower vertical radius is divided into 10 equal parts, each of these parts being equal to 6 of the upper semicircle and are actually marked 6 to 60; a curve (probably a circle, although he calls it an ellipse) passes through each of these division points and through the left and right points of the horizontal diameter. The small circle in the upper semicircle has a radius of 24 parts, the succeeding zones from the centre are as follow:

1st Zone Divided by lines into 360°.

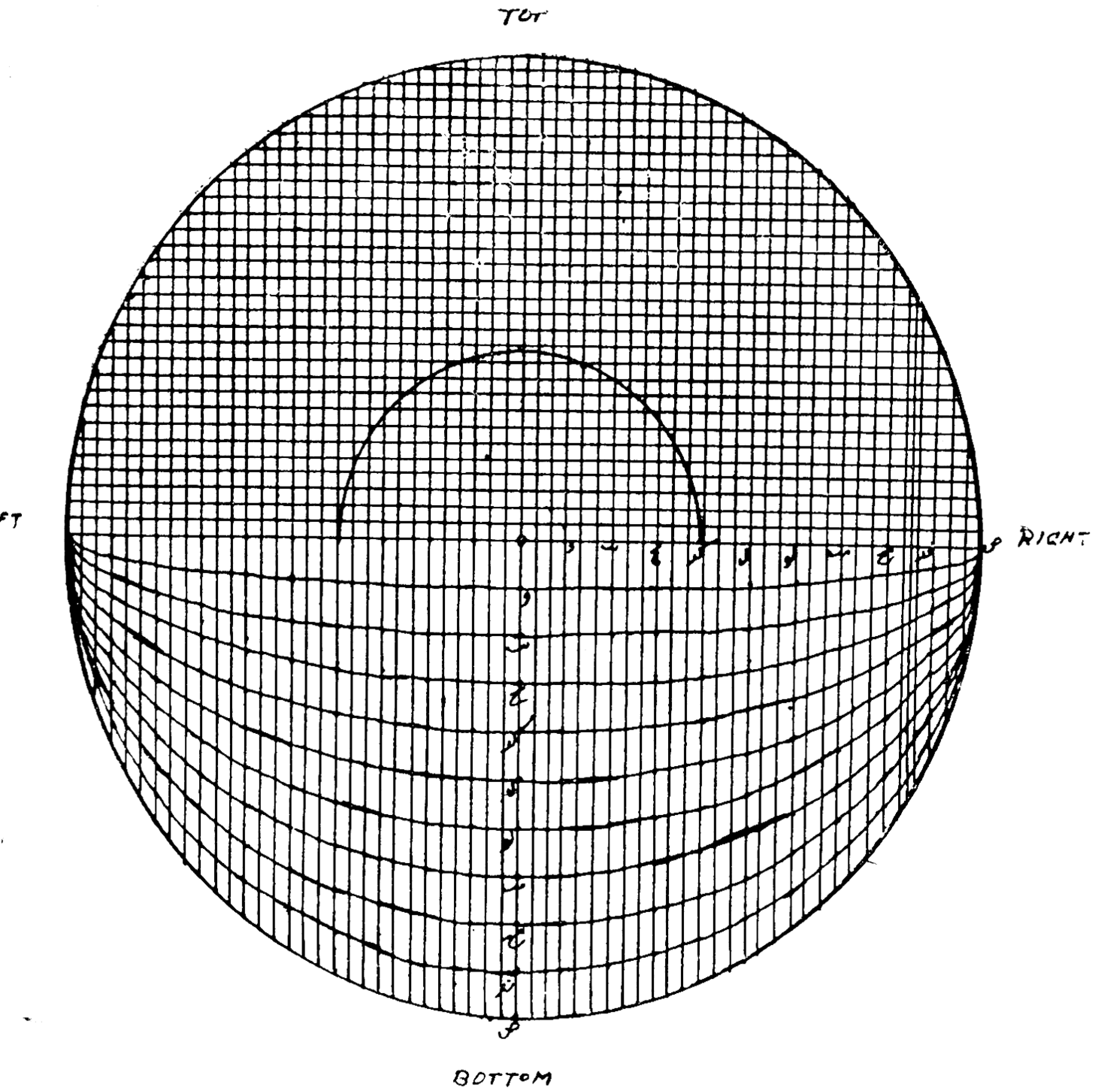


Fig. 18—Circle divided by vertical and horizontal lines into 60 equal parts and ellipses which can be drawn through two extremities of a diameter and a point on the perpendicular radius.

2nd Zone. Divided by lines into groups of 5° each; in division are the numbers from 5 to 90; for the two upper quadrants the 5° is next the horizontal line and 90° next the vertical; for the two lower quadrants the 5° is at the bottom near the vertical line and 90° at the top near horizontal; on the right side the letters read inwards and on the left outwards.

3rd Zone. Parted from the 2nd Zone by double lines. It is primarily divided into 12 divisions by lines corresponding to the 12 Christian months in the 5th Zone; each of these primary divisions is again divided into 6 parts, each of the first 5 parts corresponding to 5 days each in the 4th Zone, and the 6th part to the remaining days 5, 6 or 3 as may be, thus making up 31, 30 or 28 days for each month. Each of these small parts contains the number-letters:

ل (ل), لا (لا), كه (كه), ك (ك), يه (يه), بے (بے), ط (ط)

all read inwards.

4th Zone. Divided into 12 main parts corresponding to the Ch. months in the 5th Zone, and each main division divided into as many days as there are in each month, viz. 28, 30 or 31.

5th Zone. Divided into 12 parts, each containing the name of a Christian month, all reading inwards. January begins almost 19° to the right of the bottom—the names being in Cufic characters as—

يونيه , مايه , ابريله , مارسه , فباربر , يينير

دجنبر نونبر , اكتوبر , ستنبر , اغشته , يوليه

i.e. in Arabic characters as—

يونيه , مايه , ابريل , مارس , فبارير , ينير

دجنبر , نونبر , اكتوبر , ستنبر , اغشت , يوليه

i.e. Janier, Fabārier, Mārs, Abril, Māye, Juniye, Juliye, Agast, Satmbar, Octubar, Navambar, Dedjambar.

6th Zone. Divided into 12 parts, each containing a name of the sign of the Zodiac. Al-Hamal (Aries) begins at the right with the 14th day of March, ♋ (Cancer) at the top, *et cetera*--

(الجوز) بالحوز, (الثور) بالثور, (الحمل) بالحمل

, (السنبله) بالسنبله, (الاسد) بالاسد, (السرطان) بالسرطان

, (القوس) بالفوس, (العقرب) بالعقرب, (الميزان) بالميزان

(الحوت) بالحوت, (الدلو) بالدلو, (الجدى) بالجدى

i.e. Al-Hamal, Al-Thur, Al-Jauz, Al-Sarṭān, Al-Asad, Al-Sumbale, Al-Mizān, Al-'Aqarab, Al-Qaus, Al-Djaddi, Al-Delv, Al-Hut. All read inwards.

7th Zone. Divided into spaces of 5° each by lines, each division containing the letter-numbers ه to ل, 5 to 30 corresponding to the signs of the Zodiac in the 6th Zone, there being thus 6 divisions to each sign:

ل, كه, ک, يه, ے, ه i.e. ل كه ک يه ي ه

i.e. 5, 10, 15, 20, 25, 30. All read inwards.

8th Zone. Divided into 360°, divided into groups of 5 each corresponding to the divisions in the 7th Zone.

9th Zone. (a) Upper semicircle divided into spaces of 5° each, marked in both quadrants from ه to ض, from the horizon to the top, the letters in the right quadrant reading inwards and in the left reading outwards.

(b) Lower semicircle. The 9th Zone is divided into two concentric parts, the inner Zone contains the letter-numbers ب, د, و, *etc.*, beginning at the bottom, ب corresponds to about 9½°, د to 19°, و to 26½°, ح to 34°, ى to 40°, يب to 45°, يه to 51½°, يح to 56°, کا to 60°, كد to 63½°, كح to 66½°, لب to 69¾°, لو to 71¾°, مب to 74¼°, مح to 76¼°.

This is the same in both quadrants, except that the left quadrant reads outwards and the right inwards.

The outer Zone is divided into as many parts as are expressed by the corresponding numbers in the inner zone. *In fact the whole is a shadow scale for a gnomon of 12 digits* ظل اصابع مستوى

zill-i-asāb'a Mustawi, direct shadows in digits. pp. 7—10.

[Note: tan 9°½ = .167 = 2/12 approx.
tan 19° = .3443 = 4/12 „
tan 26°½ = .4986 = 6/12 „
tan 34° = .6745 = 8/12 „
tan 40° = .8391 = 10/12 „
tan 45° = 1 = 12/12 „
tan 51°½ = 1.2572 = 15/12 „
tan 56° = 1 4826 = 18/12 „
tan 60° = 1.7321 = 21/12 „
tan 63°½ = 2.0057 = 24/12 „
tan 66°½ = 2.2998 = 28/12 „
tan 69°¾ = 2.7114 = 32/12 „
tan 71°¾ = 3.0324 = 36/12 „
tan 74°¼ = 3.5461 = 42/12 „
tan 76°¼ = 4.0873 = 48/12 „]

EXPLANATION BY J. DE REY PAILHADE, FROM P. 23.

The face contains three things: (1) Un calendrier perpētuel musulman; (2) Un calendrier perpētuel chrétien; (3) Une table de concordance des années musulmanes et chrétiennes.

Les documents relatifs a chacun deux sont plus ou moins enchevêtrés les uns dans les autres; ce qui porte à croire que cette pièce était une sorte d'instruction propre à dresser des calendriers prepétuels plus pratiques, plus faciles à consulter.

Dans les explications que nous allons donner, les cercles seront toujours comptés à partir du centre; (P. 24) des renvois indiqueront les chiffres romains dont ils sont accompagnés dans la description et dans la traduction qui précedent. Nous nous bornerons à représenter les lettres de l'alphabet arabe par leur valeur numérique.

Two hypotheses involved: (1) The Hegira began on Thursday, 15th June 622 A.D., as according to all astronomers, the religious usage makes it begin on Friday, 16th June. (2) The Christian bissextile year is reckoned as the one which on division by 4 leaves 3. The coptic year is regulated according to that rule.[1]

Note: 1. L'an 1 du calendrier copte ou Ère des Martyrs commence de vendredi 29 aout de l'an 284 apres J. C. et finit le vendredi 28 aout de l'année suivante. (Voir l'Annuaire du Bureau des longitudes, 1890.

‘Abd El Hâdy Madjâ el Abyâry, auteur du so‘ud el matâlé le so‘aud el matâlé, ouvrage imprimé a Boulâq en l'année 1283 de l'hegire (1866), s'exprime ainsi (t. II, p. 95): “Si tu veux connaître l'année bissextile à l'aide du calcul, divise par 4 l'année copte donnée. S'il reste 3, elle est bissextile; dans le cas contraire, elle est simple.” Il en est de même pour Abou'l Hassan ‘Aly de Maroc en ce qui regarde l'année grecque (ère des Seleucides). “Il suffit de diviser le millésime de l'année proposée par 4; s'il reste 3, elle est bissextile; autrement elle ne l'est pas.”

(P. 25) Cette manière d'intercaler l'année bissextile ne donne jamais qu'une différence d'un jour par rapport au calendrier julien et une seule année bissextile par période de quatre ans.

Cette particularité présentée le calendrier de l'astronome de Seville est très curieuse et mérite d'etre signalée d'une façon spéciale. Nous rechercherons plus tard les raisons qui ont pu décider Mohammad ebn Fatoûh à faire usage d'un calendrier chrétien disposé de la sorte.[1]

General considerations: The Julian year is of 366 days every 4th year.

(P. 26) Mussalman year based on a cycle of 30 years, 19 of 354 days and 11 of 355 days. The order of the bissextile in the Mussalman Calendar varies; Md. Ebn Fatouh has adopted the 2nd, 5th, 8th, 10th, 13th, 16th 18th 21st, 24th, 26th and 29th; the Annuaire of the Bureau de Longitudes gives the 7th and 15th as bissextiles and 8th and 16th as ordinary following

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Note: 1. He gives the differences between the two methods by an example, viz.:—

Ebn Fatoûh		*Regular Method.*
28 February 959 (bissextile)	corresponds to	28 Feb. 959 (ordinary)
29 ,, ,, ,,	,,	1 March ,,
31 December ,, ,,	,,	1 Jan. 960 (bissextile)
1 January 960 (ordinary)	,,	2 ,, ,, ,,
28 February ,, ,,	,,	29 Feb. ,, ,,
1 March ,, ,,	,,	1 March ,, ,,

Olough Bey, Gravius and 'Abd el Hâdy[1].

Note: 1. Abou'l Hasan Aly de Maroc[(A)] has adopted as bissextile the 7th instead of the 8th. Navoni (Mines de l'Orient, t. iv, p. 38.) makes the 16th year bissextile; otherwise he agrees with Gravius. M. St. Lane Pole (Cat. of Gr. Coins, Add. vol. i-iv) follows Gravius, but marks the 28th year as bissextile and the 26th as ordinary. As the result, for example:—

According to Fatouh	*According to the Annuaire.*
1 Moharram I = 15 July 622	
2 ,, I = 16 July 622	= 1 Moharram I (16 July 622)
2 ,, VII (ordinaire)	= 1 ,, VII (bissextile)
29 Dou'l Hadjdjah VII (ord)	= 28 Dou'l Hadj. VII ,
1st Moharram VIII (Bissextile)	= 29 ,, ,, ,,
2nd ,, ,, ,,	= 30 ,, ,, ,,
3rd ,, ,, ,,	= 1st Moharram VIII (ordinaire).
29th Dou'l Hadj: VIII ,,	= 27th Dou'l Hadj ,, ,
30 ,, ,, ,, ,,	= 28th ,, ,, ,,
1st Moharram IX (ord:)	= 29th ,, ,, ,,
2nd ,, ,, ,,	= 1st Moharram IX. ,,

Cette différence se reproduit périodiquement chaque trente ans. Ce tableau servira à passer d'un systeme a l'autre. La différence est de deux jours pour la huitième et la seizième année du cycle de trente ans, et d'un jour pour toutes les autres années.

Note A.- This astronomer (Abou'l Hasan 'Aly) has given two methods of calculating the Mussalman bissextile. (a) Divide the date by 30, if there is no remainder it is not bis. If there is a remainder, multiply by 11 and divide by 30; if the remainder is more than 15 and less than 27 the year is bis., otherwise it is not. (b) If the date is less than 30 and is 2,5,7,10,13,16,18,21,24,26 or 29, the year is bis. If it is larger than 30, divide by 30, and if the remainder is one of the other members, it is bis; otherwise not. (Sédillot's Traduction, t. I., p. 91). He also quotes Olough Beg's Prolegomena, (p. 12-13 of the Persian text); he quotes the formulae:

بهز یجهح ادوط and بهز یجوح ا د و ط:

'Abd el Hâdy Madjâ (t. II., p. 95) says: "Le moyen de reconnaître une année bissextile d'une année commune est celui-ci; apres

(P. 27). The Mussalman months are named as follows and contain the following number of days according (P. 28) to the rule followed by the astronomers."

In this perpetual calendar the week-days (jours de la sémaine ou féries) are represented by numerical letters, 1 = Sunday, *etc.* If it comes out more than 7, deduct 7 as often as possible and remainder denotes the week-day.

(P 29). Divide into ten parts; a description of the calendars, and an appendix with tables, "comme nous pensons que l'astronome de Séville en avait inséré dans l'explication écrite de son système chronologique.

CALENDRIER CHRETIEN PP. 29-40

The Numbers in Zone I–Bis are multiples of 28 and thus the Christian year (millesime) can be divided into periods of 28 years (constituting the "solar cycle") and the remainder (reste) ascertained. This remainder is the number of the year in the cycle, and corresponds to the number in Zone IX ; the corresponding number in Zone VIII is the *sign* (signe) for the year, *i.e.* the *week-day* (férie) of *1st January reduced by 1.* Zone VI (bis) gives the week day of the 1st of each month given in Zone V. The number in Zone VIII plus that in Zone VI gives the number for the month. Due allowance should be made for leap years, which Ibn Fatoûh has not made, by adding 1 to the months from March onwards.

For any date (quantième) subtract 1 and divide by 7 and add the remainder to the week-day in the month. Thus for 9th May 1453 (the date of the capture of Constantinople by Mahommed II,

1453 less 1400 = 53, less 28 = 25. For 25 (year of solar cycle) in Zone IX, we have 1 in Zone VIII; for May in Zone VI, we have 2 in Zone V., for the date 9 less 1 we have 8. *i.e* 1+2+8=11, minus 7 = 4, *i.e.* Wednesday. He gives more convenient tables from which by mere inspection the week-day of the Julian calendar may be ascertained ; also a small table showing the number of days

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avoir retranché successivement 30 de la date arabe donnée, on passe avec le reste sur les lettres de ce vers:

كف ا لخليل كفه ديانه عن كل خل حبه فصانه

Ce qui tombe sur une lettre sans point est une année simple, et ce qui coincide avec une lettre à point, une année bissextile."

of difference for getting the week day of the Gregorian dates, *viz.* From the week days for the Julian

period from 5th October 1582	to 18th February	1700	deduct	10
19th Feb.	1700 to 17th Feb.	1800	„	11
18th Feb.	1800 to 16th Feb.	1900	„	12
17th Feb.	1900 to 15th Feb.	2100	„	13

At P. 31 he quotes other perpetual calendars: (1) of M. Lucas in the Revue scientifique (2^e semestre 1883, p. 812); (2) of La Nature of 17th October 1885; (3) that given in Le Correspondant of 10th June 1891.

PARTIE RELATIVE AU CALENDRIER MUSULMAN
(PP. 41-47.)

The astrolabe divides the Era into periods of 210 years, each of 7 cycles of 30 years. Zone I gives the periods of 210 years and multiples of the same. Zones II, III and IV—Bis give the Signes (excess of week days) for each cycle in a period, the number of the years being given in Zone IV and the Signum in Zone III. Zones II, III and IV give the Signe for each year in the cycle, the cycle being divided into parts of 8 years; when the year of the cycle is more than 8, divide by 8, and take the remainder as the indicator; Zone IV contains the years of the cycle, or the remainder after division by 8 of the years; Zone III the Signes, and Zone II shows the year in which is Kabisa or one day more. Zones V and VI give the months and corresponding Signa. To get the week day for the beginning of any month add the signa in Zones III (b), III and V; for any other date add 1 minus the date. Thus, *for 17th Safar 1308*

	1308	For complete cycle year 30	
Zone I	1260	by Zone III (b)	5
	48	18 years of cycle by	
Zone I	30	Zone III, (18/8) r = 2	1
	18 year of cycle	1st Safar by Zone V	3
		For 17th	16
			25

(25/7) r = 4, *i. e.* Wednesday.

For the year 1 Moharram I.

For the period take the signum for 210, Zone III ... 7

As that is the one repeated for each period.

1 year Zone III ... 4

Moharram I ... 1

12

(12/7) $r = 5$ *i. e.* Thursday.

At P. 47 he says that the "Annuaire du Bureau des longitudes" indicates Thursday for 17th Safar 1308 because it begins the Era with Friday 16th July 622. Whereas, Ibn Fatoûh begins like the astronomers with Thursday 15th July 622.

NOTE EXPLICATIVE SUR LE CALENDRIER PERPÉTUEL CHRETIEN. (PP. 47-50)

On peut imaginer une infinité de calendriers perpétuels.[1]

Ce cycle (*i.e.* the solar cycle of Ibn Fatoûh) est identique au cycle solaire du calendrier copte qu'on trouve dans le So'oûd el matâle (Cf. Appendix A), et qui donne la férie du 1er Aout. Nous pensons que cette concordance absolue des nombres provient de ce que la connaissance plus répandue, à cette époque-là, dans les pays orientaux; du calendrier copte que du calendrier julien, aura décidé l'astronome de Séville à attribuer le jour supplémentaire aux années dont le millésime divisé par 4 donne 3 pour reste.

Note: 1. Nous signalerons spécialement le calendrier perpétuel julien et grégorien de l'Annuaire du Bureau des longitudes (année 1890). The base of this calendar is the Dominical Letter of 1st January in each year.

Le traite des cadrans solaires par M. de la Prise (Caen, 1781) contient la description d'un calendrier perpétuel mathématique, à base de *concurrents* et *réguliers solaires*. Ce calendrier a une certaine ressemblance avec celui d'Ebn Fatoûh. Les *concurrents* correspondent aux signes des années de la table B (Zones VIII and IX, the signa beginning with 5, 6, 7, 1 ; 3, 4, 5, 6, *i.e.* with the 28th year of Ibn Fatoûh), et les réguliers solaire aux signe de mois de la Table C (Zones V and VI, viz. 2,5,5,1,3,6,1,4,7,2,5,7, in common years; 6,2,4,7,2,5,1,3,6,1 in bissextile years).

Comme on le sait, les Musulmans joignent (P. 50) généralement aux dates le nom du jour, de sorte qu'ils lévent ainsi toute ambiguité.

NOTE EXPLICATIVE SUR LE CALENDRIER PERPÉTUEL MUSULMAN. (PP. 50-56).

Ibn Fatoûh has avoided giving a table for all the 210 years by dividing it into 7 parts of 30 years each. Special tables are given for finding the week day (Ferie) of the Musalman calendar without calculation. There are three tables; the *first* gives the 'Signe', (Le signe est la ferie du 1^{er} moharram diminuée de 1) of the year, the *second* the week-day of the 1st of each month for each year-signe, and the *third* the week day for each date corresponding to the week-day for the 1st of the month.

DESCRIPTION ET USAGE DE CES TROIS CERCLES. (P. 56)

(Zones X, XI, et XII).

Zone XI contains the Musulman years, Zone X the number of years by which they exceed the Christian, and Zone XII the number of days (less one) by which the corresponding Christian years exceed the Mahmedan. Thus the first three numbers, $\overset{1}{\underset{2}{19}}$ indicate that 2^{e} Moharram *19* A. H. = 1st January 640 A. D. (622 + 19-*1*); and the 11th Series $\overset{11}{\underset{6}{355}}$ indicate that 6th Moharram 355 A. H. = 1st January 966 A. D. (622 + 355-11).

The author has given (at p. 57) similar figures upto A. H. 1429 for 13 more cycles. At p. 60 he gives the correspondences in which Ibn Fatoûh's figures differ from the actual figures by taking as bissextile the years divisible by 4, instead of those leaving remainder 3. (p. 61). This table enables one to determine the Christian year corresponding to Hegri cycle: for 613 Higri the year of manufacture of the astrolabe, subtract, the next lower in the table, viz. 590; then the 1st January 1217 (622 + 613-*590-18*) fell in 613 A. H., or 613 A. H. corresponded to 1216-17 A. D.

By adding 170 days to 15th July 622 we get 1st January 623 = 23rd Jamadi II A. H. 1.

30 Musulman years = 10631 days; 3 years = 1063 or 1064 days; 33 = years = 11694 or 11695 days; 32 Julian years = 11688 days. Thus 32 Julian years = 33 Higri years—6 or 7 days; and 33 Julian years = 34 Higri years + 4, 5, or 6 days.

(P. 66-71) Tables for ascertaining any Christian date Corresponding to a Mohammedan.

(P. 71-72) Md. Ibn Fatoûh probably did not give the actual Christian years, but only the differences because he wanted to bring out the law: "qui a présidé à la construction de ce systeme chronologique."

Number of days elapsed of the year is the "Quantième de l'annee". "Le nombre des jours écoulés depuis le commencement de l'année.'

PP. 179-181.

Notice of "IL VALORE METRICO DEL GRADO DI MERIDIANO SECONDO

i GEOGRAFI ARABI, par C. A. Mallino. Turin, 1893, in-8^{e}, III op. 39 pages.

It is given as 56 2/3 miles in a degree as measured by Al'Mamoun.

56 2/3 × 1973.2 metres = 111814.67 metres.

Actually it should be 110938.0 Metres; thus there is only an error of 878. 67 metres. Mallino has given the various Arab measures, thus supplementing Sauvaire's materiaux de Mētéorologie Musulmane. (Journal Asiatique, 1886, t. II., pp. 479-536).

PART II.

PP. 185-231.

USAGE DU TABLEAU DES CONCORDANCES

"Quantième de mois" monthly date.

(P. 187). **No.** 1. "Tables des concordances des dates des calendriers arabe, copte, grégorien, israélite, Julien et républicain", par M. Lacoine, Paris, Baudry, 1891, 1 Vol. gr. in-8^{o}.

(P. 191-194). These tables also serve to find the *epact* of a year, (*i. e.* of 1st January for the year) as well as Easter Sunday, ("Fête de Paques" or "Paques") very approximately.

The rule of the Council of Nice as to Easter (p. 192).

Note p. 193. In the Comptes Rendus de l'academie des inscriptions et belles-lettres (Bulletin of-May-June 1892) there is a comparative table of the Catholic, Russian and Jewish Easters from 1890 to 2000 A. D.

The year 1 A. D. is 10th of the Solar cycle; its Golden number or Lunar cycle is 2, and it is the 4th of the Roman Indiction. One gets these figures for any other year by adding these numbers to the year reduced by 1 and dividing respectively by 28, 19 and 15; and noting the remainder r *e. g.*–for 1893—

(*a*) $\left(\frac{1892+10}{28}\right)$ $r = 26$ Golden cycle.

(*b*) $\left(\frac{1892+2}{19}\right)$ $r = 13$ Lunar cycle or Golden number.

(*c*) $\left(\frac{1892+4}{15}\right)$ $r = 6$ Indication.

The Dominical letter is A, as 1st January 1893 is a Sunday.

DOS DE L'ASTROLABE. (P. 194–205)

The outermost zone contains a circular scale of shadows in place of the usual "carré de ombres", "square (scale) of shadows". The shadows are horizontal ones of a vertical gnomon (style) 12 digits (doigts) high.

$w = \text{arc tang.}\ \frac{\theta}{12}$, where θ is the length of the shadow; (in ordinary language, $w = \tan^{-1}\left(\frac{\theta}{12}\right)$ = zenith distance). "La division de l'appareil est bien fait".

He gives the following table for length of shadow and Zenith distance (Z. D.): (P. 197).

Length in digits	*Z. D.*	*Tangent of Z. D.*
1	4° 46′	0. 0834 = 1/12 Approx.
2	9° 28′	0. 1667 = 2/12 "
3	14° 2′	0. 2499 = 3/12 "

Length in digits	*Z. D.*	*Tangent of Z. D.*	
4	18° 26′	0. 3333 = 4/12	Approx.
5	22° 37′	0. 4166 = 5/12	,,
6	26° 34′	0. 4991 = 6/12	,,
7	30° 15′	0. 5832 = 7/12	,,
8	33° 41′	0. 6665 = 8/12	,,
9	36° 52′	0. 7499 = 9/12	,,
10	39° 48′	0. 8392 = 10/12	,,
11	42° 31′	0. 9168 = 11/12	,,
12	45° 00′	1. 0000 = 12/12	,,
13	47° 17′	1. 0831 = 13/12	,,
14	49° 24′	1. 1667 = 14/12	,,
15	51° 20′	1. 2497 = 15/12	,,
16	53° 8′	1. 3335 = 16/12	,,
17	54° 47′	1. 4704 = 17/12	,,
18	56° 19′	1. 5004 = 18/12	,,
19	57° 43′	1. 5828 = 19/12	,,
20	59° 2′	1. 6669 = 20/12	,,
21	60° 15′	1. 7496 = 21/12	,,
22	61° 23′	1. 8328 = 22/12	,,
23	62° 27′	1. 9169 = 23/12	,,
24	63° 26′	1. 9999 = 24/12	,,
25	64° 22′	2. 0831 = 25/12	,,
26	65° 13′	2. 1659 = 26/12	,,
27	66° 2′	2. 2478 = 27/12	,,
28	66° 48′	2. 3332 = 28/12	,,
29	67° 31′	2. 4162 = 29/12	,,
30	68° 12′	2. 5002 = 30/12	,,
31	68° 50′	2. 5825 = 31/12	,,
32	69° 26′	2. 6152 = 32/12	,,
33	70° 1′	2. 7501 = 33/12	,,
34	70° 34′	2. 8343 = 34/12	,,
35	71° 5′	2. 9186 = 35/12	,,
36	71° 34′	2. 9997 = 36/12	,,
37	72° 4′?	3. 0936 = 37/12	,,
38	72° 28′	3. 1652 = 38/12	,,
39	72° 54′	3. 2506 = 39/12	,,
40	73° 18′	3. 3332 = 40/12	,,
41	73° 41′	3. 4167 = 41/12	,,

Length in digits	*Z. D.*	*Tangent of Z.D.*
42	74° 3′	3. 4996 = 42/12 Approx.
43	74° 24′	3. 5618 = 43/12 ,,
44	74° 45′	3. 6676 = 44/12 ,,
45	75° 4′	3. 7507 = 45/12 ,,
46	75° 23′	3. 8345 = 46/12 ,,
47	75° 41′	3. 9179 = 47/12 ,,
48	75° 58′	3. 9998 = 48/12 ,,

[The last column is added to show clearly how the length in digits, divided by 12, gives tangent of the corresponding Zenith distance: vide notes on *aqdām* and *aṣabi'a* on pp. 8-10].

(P. 198) *Description of the other zones.* "La ligne de l'origine du Bélier passe par le milieu du 14° jour de mars. Il n'est pas douteux qu'il ne faille lire 13, 5. C'est effectivement pendant le 13ᵉ jour de mars, plus un demi–jour, qu'avait lieu l'équinoxe de printemps à cette époque.

(At p. 198 and 199) Note 1.- In this he finds the equinox for 1213 A. D., from that for 1890. That for 1890 took place at Paris at 3-30 P. M. (= .66 of a day after midnight) on 20th March New Style (8th March Old Style); as Seville is 33′ West of Paris it took place there at .635 of a day after midnight. As the equinoctial year is 365. 2422 days, for every 4 years anterior it takes place on the same date + .0312 of a day (1–4 × .2422); hence in *1210* A. D. (1890 – 4 × 170) it took place 170 × .0312 days later, *i. e.* on 13th March at .939; by adding for 3 years it took place in *1230 A. D. on 13th March .665 of a day.* In the astrolabe it is shown as in the middle of the 14th of March. The difference is due to the Musulman mode of counting from sunset. ("La regle astronomique d'alors, probablement de 12 heures, à partir du midi precedent.")

The Tolouse astrolabe constructed in Morocco in 1216 A. D. makes the Vernal Equinox begin with 14th March. (The true time is 13th March .391 after midnight).

The astrolabe shows that ♈ (Aries) begins at 13. 5 March, ♋ (Cancer) with 15. 0 June, ♎ (Libra) with 16. 0 September, ♑ (Capricorn) with 14. 0 December.

(P. 200)

Thus, according to Ibn Fatoûh	According to Ann. du Bur. Long. 1890, p. 140; in the XIIIth Century they took–
Spring was 93 days, 12 hours	93 days, 6 hours for Spring
Summer was 93 " 0 "	93 " 6 " " Summer
Autumn was 89 " 0 "	89 " 9 " " Autumn
Winter was 89 " 12 "	89 " 9 " " Winter

The difference is excusable considering the difficulty of engraving such minute divisions on copper.

(P. 201): This arrangement enables us to find the position of the sun on any given date by simply putting the "Alʿidāde" and reading off.

(Pp. 201-205) treat of the central part of the lower semicircle of the back. He takes the figures to be ellipses (except the outer one which is a circle,) whose semi-major axis is equal to the radius of the outer circle containing 60 parts, and whose semi-minor exes are respectively 6, 12, 18 etc. parts upto 60. He calculates the ellipses as projections of the outer-circle, taking the angles to be $\sin^{-1}\frac{6}{60}$, $\sin^{-1}\frac{12}{60}$, etc., and calling them χ. He also calculates the length of each ordinate in any ellipse corresponding to a given abscissa by taking it as a projection of a corresponding line in the originating circle, and he calls the angle, σ *e. g.*

Thus for the abscissa 48, the value of σ is $\cos^{-1}\left(\frac{48}{60}\right)$, and the ordinate is $\frac{42}{60} \times \sin\left(\cos^{-1}\frac{48}{60}\right)$ [Here a multiplying factor 60 seems to have been omitted through oversight.]

He gives the tables for χ and (practically the same) for all the 10 figures, i. e. for all the angles whose cosines are respectively $\frac{1}{10}$, $\frac{2}{10}$, $\frac{3}{10}$, etc;

	cos χ	χ	sin χ
1/10	(6/60)	84°15′	.9950
	2/10	78°28′	.9798
	3/10	72°33′	.9540
	4/10	66°25′	.9165
	5/10	60° 0′	.8660
	6/10	53° 8′	.8001
7/10	(42/60)	45°34′	.7141
	8/10	36°52′	.6000
	9/10	25°50′	.4358
	10/10	0° 0′	.0000 ;

thus he finds the exact value in the above example to be 25.2 . He then says (p.203) "La valour exacte de 60 × cos σ × 42/60 étant 25.2. On voit que le tracë de cette ellipse n'est pas absolument rigoureux. Il est trés probable que ces ellipses ont été tracées en suivant le contour d 'un gabarit pose sur l 'astrolabe.

M. Sedillot ne signale aucune disposition de ce genre.

[There is some confusion in what is stated above. The ellipses are projections of circles at angles $\cos^{-1}(\frac{6}{60})$, $\cos^{-1}(\frac{12}{60})$, $\cos^{-1}(\frac{18}{60})$, etc., and not at angles $\sin^{-1}(\frac{6}{60})$, $\sin^{-1}(\frac{12}{60})$, $\sin^{-1}(\frac{18}{60})$ etc.; and the value of the ordinate of the circle for abscissa 48 is 60sin σ; and the value of the corresponding ordinate in the ellipse is (60sin σ) cos χ; and for b (semi-minor axis) = 42, cos χ is $\frac{42}{60}$, sin σ is $\sin^{-1}\left(\cos\frac{48}{60}\right)$, *i.e.* $\sin^{-1}\left(\sin\frac{3}{5}\right)$, *i.e.* 0. 6.; hence the value of the ordinate of the ellipse = (60 sin σ) cos χ = (60 × 0.6) $\frac{42}{60}$ = 25·2.]

(P. 205). Les tables des angles χ et σ ont été calculées et dressées uniquement pour donner une idée des procédés des Arabes, qui avaient aussi á leur disposition de grands appareils d'observation. Les graphiques des astrolabes ne pouvaient donner les valeurs des lignes trigonomét riques avec assez d ' exactitude. Il recouraient alors á leurs tables du genre de celles que nouse dononns.

On voit que le dos de cet astrolabe est certainement aussi remarquable que le *systeme chronologique.*

Actual measurement of the photo shows the outer circle (of the sine scale on the back) as 89 Mm. in diameter, and the inner small circle (equal to 24 parts in radius) as 17½ Mm. The actual measurements in millimeters of ordinates for the following abscissae for the different ellipses are as follows :–

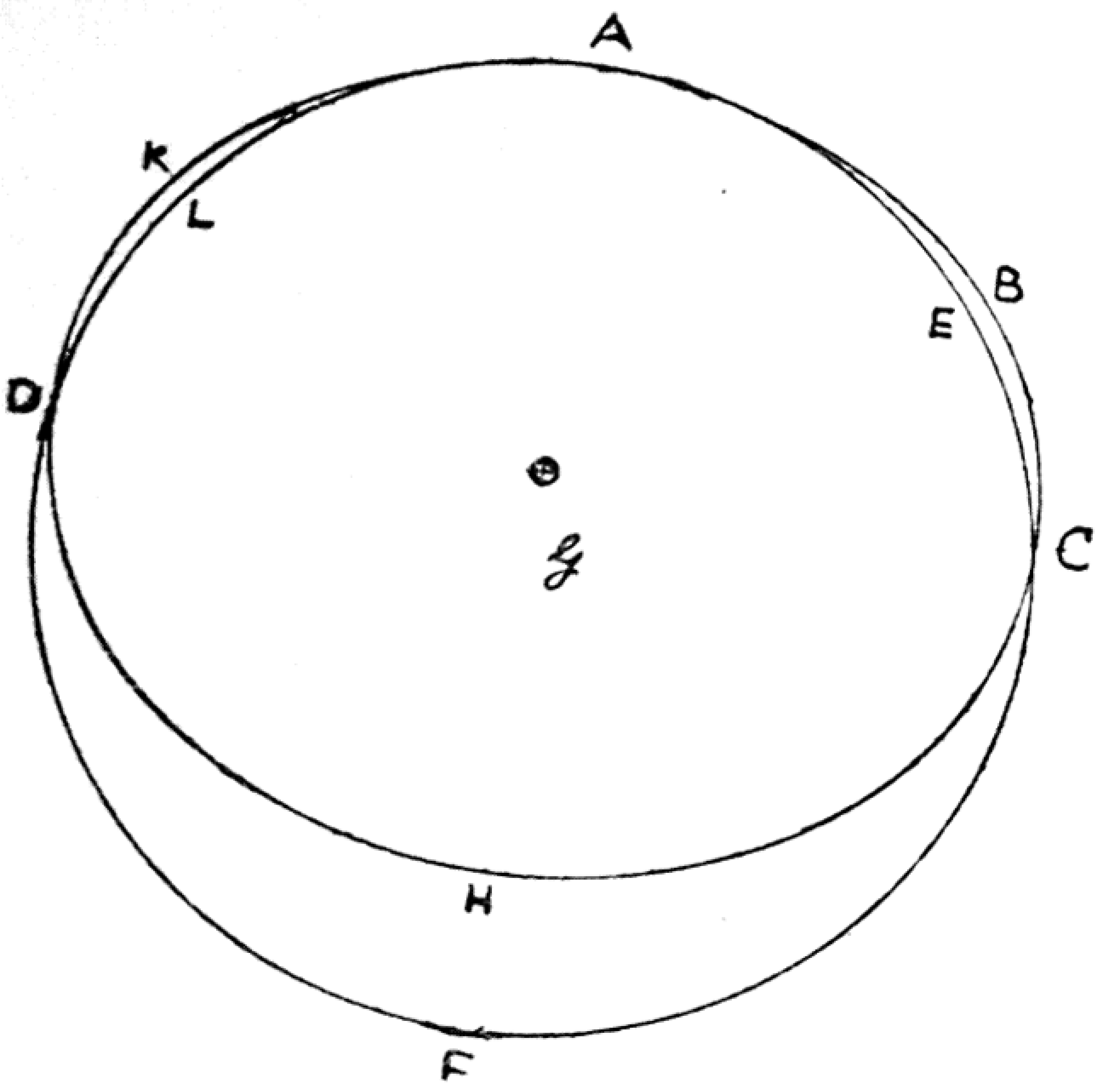
	Abscissae (x) in parts										
Semi-diameter[1] (b) of ellipse in parts	6	12	18	24	30	36	42	48	54	52	56
6	4½	...	...	4	4	3½	...	2¾	...	2	1¾
12	9	...	...	8	7½	7	...	5½	...	4	3½
18	13½	...	...	12¼	11½	10½	...	8	...	6	5
24	17½	...	...	16¼	15¼	14	...	10½	...	8½	6½
30	22	...	...	20½	19½	17½	...	13½	..	10½	8
36	26¾	...	...	24½	23½	21½	...	16½	...	13½	9½
42	31	...	...	28½	26½	25	...	19	...	15½	11
48	35½	...	...	32½	31	28½	...	22	...	17½	12
54	39½	...	...	36½	35	32	...	25	...	20½	13½
60	44	...	...	40¾	39	35½	...	27½	...	22	15

[1. The word *diameter* seems to have been put down through oversight for *minor-axis*. The numbers in horizontal lines represent the values of the ordinates in the ellipses with semi-minor-axes-6,12,18,..., for abscissae 6,12,18,.... given at the heads of the columns.

Mr. MPK has measured and read out the values of the several ordinates as tabulated above from a photograph of the instrument, but the readings given by him do not agree with numbers which we get by direct calculations. The following tables will show how widely these values of calculated ordinates and the measures given by Mr. MPK in his above Tables, differ.

Values of x	6	12	18	24	30	36	42	48	54
values of y for b=6	5.9	5.8	5.7	5.5	5.2	4.8	4.6	3.6	2.6
b=12	11.9	11.7	11.4	11	10.4	9.6	8.5	7.2	5.2
b=18	17.9	17.6	17.2	16.5	15.5	14.4	12.8	10.8	7.8
b=24	23.8	23.5	22.9	22	20.7	19.2	17.1	14.4	10.5
b=30	29.8	29.4	28.6	27.5	26	24	21.4	18	13
b=36	35.8	35.3	34.3	33	31.2	28.8	25.7	21.6	15.7
b=42	41.8	41.2	40	38.5	36.4	33.6	30	25.2	18.3
b=48	47.7	47	45.7	43.9	41.5	38.4	34.3	28.8	20.9
b=54	53.7	52.9	51.5	49.5	46.7	43.2	38.5	32.4	23.8
b=60	59.7	58.7	57.2	54.9	51.9	48	42.8	36	26.2

Investigation as to the Lengths of Ordinates of Ellipses and Circles through three ends of the principal axes of the ellipses.



ABC is a quadrant of an ellipse $ABCHDK$, and AEC an arc of a circle $AECFDL$ passing through the points D, A, C. The equation to the ellipse is $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$; taking the axes of the ellipse as co-ordinate axes.

The diameter of the circle is $AO+OF=b+\frac{a^2}{b}=\frac{a^2+b^2}{b}$; G being the centre of the circle, $OG=\frac{1}{2}\left(b+\frac{a^2}{b}\right)-b=\frac{a^2-b^2}{2b}$.

The equation to the circle is therefore, $x^2+\left(y+\frac{a^2-b^2}{2b}\right)^2=\left(\frac{a^2+b^2}{2b}\right)^2$.

For the ellipse, $y^2=b^2\left(1-\frac{x^2}{a^2}\right)$, or $y=\frac{b}{a}\sqrt{a^2-x^2}$.

For the circle, $y=\sqrt{\left(\frac{a^2+b^2}{2b}\right)^2-x^2}-\frac{a^2-b^2}{2b}$.

Example (1)—$a=60$ parts, $b=42$ parts, and $x=48$ parts.

In the ellipse $y=\frac{7}{10}\sqrt{3600-2304}=\frac{7}{10}\sqrt{1296}=\frac{7}{10}\times 36=$ **25.2.**

Now $\frac{a^2+b^2}{2b}=\frac{a^2}{2b}+\frac{b}{2}=\frac{3600}{84}+21=42\frac{6}{7}+21=63\frac{6}{7}$; and

$\frac{a^2-b^2}{2b}=\frac{a^2}{2b}-\frac{b}{2}=42\frac{6}{7}-21=21\frac{6}{7}$;

$\therefore y$ (in the circle) $=\sqrt{(63\frac{6}{7})^2-2304}-21\frac{6}{7}=43.27-21.85=$ **21.42.**

As 60 parts (on the astrolabe) $=\frac{89\frac{1}{2}}{2}$ Mm. $=44\frac{3}{4}$ Mm., each part is practically $\frac{3}{4}$ Mm. and each Mm. $=1\frac{1}{3}$ part.

Thus the actual 19 Mm. found on measurement on the astrolabe is equal to 25.3 parts, which shows the curve through the three points to be an ellipse and not a circle, as the ordinate is longer than the corresponding one of the circle.

Example (2) – $a = 60$ parts, $b = 30$ parts, $x = 30$ parts.

For the ellipse, $y = \frac{1}{2}\sqrt{3600 - 900} = \frac{1}{2}\sqrt{2700} = \frac{1}{2}$ $(51.96) =$ **25.98** parts, ($19\frac{1}{2}$ Mm. on actual measurement = 26 parts).

For the circle, the radius $= \frac{3600}{60} + 15 = 75$, and $\frac{a^2}{2b} - \frac{b}{2} = 45$, $y = \sqrt{(\text{radius})^2 - x^2} - 45 = \sqrt{75^2 - 30^2} - 45 = \sqrt{4725} - 45 =$ $68.7 - 45 =$ **23.7**, and as 60 parts = 44.75 Mm., 23.7 parts = 23.7 × $\frac{44.75}{60}$ Mm. = 17.8 Mm. The curve is thus an ellipse and not a circle.

The difference between the two values of "y", that for an ellipse and the corresponding one for a circle is—

$$\frac{b}{a}\sqrt{a^2 - x^2} - \sqrt{r^2 - x^2} + \frac{a^2 - b^2}{2b}, \quad \text{where } r = \frac{a^2}{2b} + \frac{b}{2}.$$

To find for what value of x, it is maximum, differentiate with respect to x and equate to 0;

i.e. $\frac{b}{a}\frac{-x}{\sqrt{a^2 - x^2}} - \frac{-x}{\sqrt{r^2 - x^2}} = 0$:

hence, either $\frac{a\sqrt{a^2 - x^2}}{b} - \sqrt{r^2 - x^2}$, or $x = 0$;

but $x = o$, obviously gives a minimum, hence $\frac{a\sqrt{a^2 - x^2}}{b} = \sqrt{r^2 - x^2}$ gives a maximum.

i.e. $a^2 (a^2 - x^2) = b^2 (r^2 - x^2)$, gives a maximum ;

or $x^2 = \frac{a^4 - b^2 r^2}{a^2 - b^2}$, but as $r^2 b^2 = \frac{1}{4}(a^2 + b^2)^2$,

$$= \frac{4a^4 - (a^2 + b^2)^2}{4(a^2 - b^2)} = \frac{(3a^2 + b^2)(a^2 - b^2)}{4(a^2 - b^2)} = \frac{1}{4}(3a^2 + b^2),$$

$\therefore x = \pm \frac{1}{2}\sqrt{3a^2 + b^2}$ gives a maximum.

e.g. take as above, $a = 60$ parts, $b = 42$ parts, then for a maximum, x must be $\frac{1}{2}\sqrt{10800 + 1764} = \frac{1}{2}(112.08)$, or $x = 56$ *approx.* gives the maximum difference of ordinates.

APPENDICES

(A)

(P. 206). Extract from the "So'oud el matâlé'", t. II. p. 96.

Method of determining the 1st of Thoth of the Coptic year, which is the first day.

Divide by 28 , and from the remainder judge by the the series—

وزاج ده و آب جـد و زاب[1]ده و زبجده زاب جه ـ فتـأ ملا

The series is 6,7,1,3,4,5,6,1,2,3,4,6,7,1,2,4,5,6,7,2,3,4,5,7,1,2,3,5. The last word فتـأ ملا is merely a "remplissage". Thus for 1582 the first date is Sunday (1).

(B)

(P.207). The first day is called مدخل (madkhal).

Abu'l 'Aly de Marve (wrote about 627 = 1229, 1230 A.D.) gives the following rule for the Madkhal of a Higri year (T.I., p. 86-88).

(P. 209). Qazwini's method. (He was at Damascus about 630 H., and completed a work in 674 = 1275, 76) ("Cosmographie", edited by Wüstenfeld, p. 73 et 74). He divides by 8 the Higri year and the days of 1st Moharram are 2,6,3,4,5,1,7,4.

Another method attributed by him to Ahmed bin Tébât.

(P.213). Olough Beg's Method ("Prolegomenes", p. 13--14, text).

(P. 216). This method for Seleucidra.

(P. 219) Abd el Hâdy Madjâ d'Abyâr (wrote after H.1279 = 1862 in Egypt) Subtract 1267, and then pick up according to remainder after dividing by 8.

اهجـز دبود

(P. 222). Remarks on the Mussalman & Christian Calendars.

I. Concordance entre le calendrier musulman et le calendrier chretien, par Soliman el Haraïri. Trans by Henri Cotelle, 2nd Dragoman at Tunis (Journal Asiatique: 1847).

II. Ideler's Memoire (Mines de l' Orient, t. iv.,p.299 et suiv.)

III. M. Lacoine's.

IV. M. Mavoni : Mines de l ' Orient (t. iv., p. 38) translation of a Turkish Rouznamé according to reform by Darendéli Mehemét Efendi.

No year begins with March so that although 1811 is given as bissextile it is really February 1812 that is of 29 days. Cycle of 8 years; letters 1,5,3,7,4,2,6,4; add 2 to Higira and divide by 8 and from the remainder obtain the Madkhal according to the letters of اهجز دبود i.e. 1,5,3,7,4,2,6,4.

Note 1. In the text ی is printed by mistake for ب.

ON THE ASTROLABE

Notice from the journal Asiatique, 1896 (9th series, vol. XIII) from M. F. Nau's article "Le Traité sur L'Astrolabe Plan de Sévère Sabokt ecrit au VIIth siècle d'après des Sources Grecques, et publié pour la première fois d'après un MS de Berlin" (pp. 56–101, 238–303).

(P. 56). The author Sévère Sabokt of Nisibis, bishop of Qenserin, flourished according to Bar Hebreus (Chron,eccl., I Col. 275) at the time of the patriarch Jean (631–649) ; took part in a controversy in Haziran 659: 11–57) ; wrote letter of Basil of Cyprus on the 14th Mon. of Nisan in 665; was distinguished in philosophical, mathematical and ecclesiastical studies ; commented on Aristotle ; Sachau published fragments of his astronomical works "Sur la terre habitée et inhabitée"; Sur la mesure du ciel et de la terre et la montagne qui est au milieu" in 'Inedita Syriaca' in 8°, Vienna 1870, pp. 127–134.

The Manuscript-Berlin, Collection Petermann No. 37. Dated year 1267 of Greeks (956 A.D.) ; badly penned letters (*It is evidently in Syriac*-M.P.K.)

(P. 58) The work-consists of two parts (1) Definition and description of the astrolabe, (2) Rules of using it, 25 rules, of which Nos. 20 and 21 are wanting owing to a missing folio. (p. 59) .

SUMMARY OF RULES : (p. 60) Principles of construction not given; merely description and rules of use for a pupil who has the intstrument in hand; hence in this text the plates are borrowed from Sedillot Memoire sur les Instruments astr. des Arabes Mem. de l'Acad. des inscriptions I^{ere} Serie, t. I, p. 22 et 153. (Cf. P. Tannery, la Geometrie Grecque, Paris, 1887 , p. 6 and 7. Tannery thinks the astrolabe goes up to Ptolemy; I think that it goes up still further).

(P. 60) IMPORTANCE OF THE WORK: (1) It is the only treatise on *the astrolabe in Syriac*. (2) It is of the 7th century and so precedes the studies of the Arabs. It must be derived from Greek sources. *Hence, it disproves a theory long accepted that the Arabs* *invented the astrolabe.* (Sedillot's work); the present treatise must have been one of the instruments of transmission of knowledge from the Greeks to the Arabs;

(P. 61) Renan has already shown that Sévère Sabokt informs us that the invention was earlier than Ptolemy; and we learn his name from the passage of Vitruvius which has long been misunderstood; the passage is "Hemicyclium excavatum "ex quadrato ad enclimaque Berosus Chaldaeus dicitur "invenisse, scaphen sive hemisphaerium Aristarchus Samius, "idem etiam discum in planitie, *arachnen* Endoxus astrologus, "nonnulli dicunt Apollonium, plinthium sive lacunar, quod "etiam in circo Flaminio est positum, Scopinias Syracusius". (This passage is quoted in the footnote at p. 64. It is from Arch. IX. 9) Archne (spider) must mean the astrolabe, a part of which is still called "the spider"; there is no reason to suppose it meant a dial or spherical dial. S. S. mentions the inventor 8 times calling him thrice "the philosopher who has made the astrolabe" and five times "the philosopher"; further he says Ptolemy constructed his tables "according to the astrolabe" "d'après l'astrolabe";

(P. 62) he also when giving the division of the climates first mentions the division according to the inventor of the astrolabe and then that according to Ptolemy, and he also mentions the obliquity given by the former as 24° and that by Ptolemy at 23°51′ which makes it certain that the former must have preceded Ptolemy.

The chief use of the astrolabe was to determine the hour either of day or night.

(P. 64) Endoxus of Cnidus (409–356 B.C.), Apollonius of Perga (2nd or 3rd cent. B.C.), Vitruvius (1st cent. B.C.), Ptolemy (2nd Cent. A.C.). Ideler taking the astrolabe to be later translated Arachne as a "sun dial"; Letronne followed him. It was known that Ptolemy had given the mathematical principles for the construction of the astrolabe; but it was supposed he only used the spherical astrolabe; the Greek work on the astrolabe of Jean Philoponus, contemporary of Sabokt, published in 1839 (Rheinisches Museum fur Philologie, t.VI, Bonn .1839) was not noticed especially as it mentions no name save that of Ptolemy and that only in one place.

(P. 65) Further in the following page Vitruvius describes the "horloges anaphoriques"; they consist of two parts a fixed tablet bearing the hours and a moveable one bearing the sun and signs of the Zodiac moved uniformly by mechanical means. It is nothing more than our astrolabe. The passage runs : (p. 66)-

"Fiunt etiam alio genere horologia hyberna quae anaphorica "dicuntur perficiunturque rationibus his: 1° Horae disponuntur ex "virgulisaeneis ex analemmatos descriptione (selon la latitude) , ab "centro dispositae in fronte; in ea circuli sunt circumdati, menstrua "spatia finientes. 2° Post has virgulas, tympanum collocatur, in "quo discriptus et depictus est mundus signiferque circulus "(le zodiaque), descriptioque duodecim caelestium signorum sit "deformata, cujus e centro deformatur conjuslibet signi spatium, "unum majus, alterum minus (voir Fig. 2). 3° Posteriori autem "parti, tympano medio axis versatilis est inclusus, inque ex aenea "mollis catena est involuta ex qua pendet ex una parte phellos "sive tympanum quod ab aqua sublevatur, ex altera aequo pondere "phelli sacoma saburrale (un sac de sable). Ita quantum ab aqua "phellos sublevatur, tantum saburrae pondus infra deducens versat "axem, axis autem tympanum; cujus tympani versatio, alias "efficit uti major pars circuli signiferi, alias minor in versationibus "suis temporibus designet horarum proprietates. 4° Namque in "singulis signis, sui cujusque mensis dierum numeri cave sunt "perfecta cujus bulla (le clou) quae solis imaginem horologiis tenere "videtur, significat horarum spatia; ea translata ex terebratione "in terebrationem mensis vertentis perficit cursum nuem. 5° "Itaque quemadmodum sol per siderum spatia vadens, dilatat "contrahitque dies et horas, sic bulla in horologiis ingrediens per "functa contra centri tympani versationem, quotidie quum trans-"fertur, aliis temporibus per latiora, aliis per angustiora spatia "menstruis finitionibus imagines efficit horarum et dierum."

(P. 66) Ptolemy did not use the astrolabe because it gives inexact results; (P. 67)-he states (a) The divisions are small; (b) The parts are moveable; (c) Each tablet serves only for a particular latitude. Hence he used more convenient instruments and the return to the astrolabe was in reality a step back and not progress.

(P. 67) *History of astrolabe summed up*: Invented by Eudoxus or Apollonius; (P. 68)-later they give the spider uniform motion by means of a float and counter-weight and made it a clock anaphorique; on account of its errors Ptolemy did not use it, save the back, for altitudes: still he gave rules of stereographic projection for its construction and certain tables, and it was always called "the astrolabe of Ptolemy". It was always used. Théon of Alexandria and Synesius have given descriptions of it although incomplete and obscure. Then in the 7th century Jean Philoponus at Alexandria and S.S. in Syria wrote long treatises on it which the Arabs studied; (P. 69) and transmitted to the westerns.

(*Note*) In Konar libraries are found treatises on the astrolabe attributed to Ptolemy, Theon of Alexandria, Ammonius *etc.*; they have been supposed to be apocryphal under the idea that the Arabs first invented it ; but now these treatises will require greater study. They used it till the 18th century (Brien's Usage de astrolabe in 1702).

It cannot be decided whether Eudoxus or Apollonius invented the astrolabe; both were capable of doing it. If it was the former, it is a question whether the Egyptians among whom he studied had not a hand in the matter.

The Syriac Text 1st part (pp. 71 to 86)

Translation of the same (pp. 87 to 101).

(P. 87) Before giving the rules for using it, for finding the hours and other results, it is befitting to state its composition and form. Its tablets[1], what number gives the longitude of the spheres of heaven, and which their latitude; the four directions.

(P. 88) *Definition* : "L' astrolobe est une instrument artificiel, composé, a l'aide duquel on détermine les étoiles, les heures, les levers, les zones tropicales, en un mot le double mouvement en longitude et en latitude de la sphere céleste et les changements des climats".

Made of brass (airain); round and plane; (P. 89) three or four tablets round and equal; placed in one which holds them all; rim of this[2] above all the tablet with the circle called Zodiac which bears the Zodia *i.e.*, signs each of 30°. Diplons or Triplons quand

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Note 1: Arabic صفيحه Greek Tumpanoi;

Note 2: Arabic Umm la Aṣṭorlabe آم الاصطرلاب;

un degré ecrit en represente deux or trois[1]; it bears outside the signs and the brightest and best known stars; the Zodiac, the stars and the whole assemblage is called ‘arachnē *i.e.*, “spider (p. 90)”;[2] round all a circle.

In the exterior tablet which encloses all the back of the astrolabe, 4 quadrants of 90°, divided by 2 straight lines, vertical and from east to west : 0° in the horizon and 90° at zenith. *A ruler* (one regle) with pointed ends; (p. 91) on this ruler two opposite tablets of about an inch (square) with holes in them[3] the length of the ruler is the diameter of the tablet; its breadth about an inch; called “dioptre”; its ends “indicatrices des degres” (index);–(note *To moirognomonion*) as they indicate in which degree of the quadrant the sun or star is when it traverses (goes along) the dioptre.

(P. 92) Hole in centre of all; with a pin in it; *this pin marks the place of the North Pole, i.e.*, the north end of the axis of the world.

On the tablets, of which we have spoken “un climat est désigné par son nom et devisé selon sa latitude et lĕ heures de son plus long jour”. Each divided into four parts like the exterior (the back); here the part above the horizon is divided into 180° : “sur cet horizon sont marqués le levant, le couchant, le nord et le midi ainsi que le lever et le coucher de tous les astres; étoiles ou planetes.” From one end of a diameter to the other in all directions 180°, with the zenith 90°. Il est evident deja que ces tablettes de l’astrolabe relatives a un climat quelconque, porteront tous jours de un degré a 90 degrés depuis le coté sud jusqu’au point (sémeion) du milieu du ciel, cest-à-dire au (p. 94) point qui est necessairement au-dessus de notre tête en quelque climat que nous sayons (zenith)”.

Le philosophe a figuré la partie du midi non seulement parce qu’au point sud commence la hauteur de la sphere, c’est-à-dire du monde, mais parce que c’est de ce coté que le circle du Zodiaque passe au-dessus de l’horizon et que la plupart des etoiles se levent

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Note 1 Sèdillot p. 179 says–Bipartium, Tripartium.

Note 2 somtimes called “the net”:

Note 3 اهدخل. This word signifies “longueur, longitude geographique, angle horaire”;

et se couchent. De ce coté se trouvent les trois Zones tropicales, qui font connaitre les diverses latitudes relatives des climats, et le cercle meridien (cercle du midi) qui lui doit son nom. Les 180 degres ou plutot les 90° cercles correspondants sont appelés "paralleles" c'est-à-dire; proches l'un de l'autre, ou qui se suivent l'un l'autre.[1] The Arabs have translated this word as Almuqantrāt المقنطرات *i.e.*, according to Sédillot, circuli progressiorum (Memoire p. 154). On les compte soit a l'est soit a l'ouest, mais tous rencontrent le cercle des 90 degrés figuré par une ligne droite qui est en verité (la méridienne). Ces paralleles ne sont pas comptés au levant ou au couchant, c'est-à-dire, sur la sphere du ciel, car telle n'est pas la pensée du philosophe qui a construit l'astrolabe, mais bien depuis le sud droit sur le meridien. Le philosophe qui construisit l'astrolabe le limita, pour tout climat, au tropique d'hiver, comme le montre la figure; aussi tous les paralleles (de hauteur) qui precedent le tropique d'hiver sont interrompus des qu'ils arrivent a cette zone puis qu'il n'y a pas de place au sud (lire "au nord") sur la tablette. Il fallut donc les figurer à (p. 95) partir de l'horizon est vers l'ouest; mais il est evident que si l'on observe le soleil, la lune ou l'une des etoiles dans le premier degre de ces paralleles dont nous parlons, ou dans le 5e ou dans le 10e degré (comme nous apprendrons à le faire dans le traité sur l'astrolabe), c'est-à-dire avant que l'astre n'atteigne le parallele du tropique d'hiver qui est le trentième dans le quatrième climat[2] peu importe que l'astre soit a l'orient ou a l'occident, nous disons toujours quil est en hauteur à ce degré au sud du tropique d'hiver, parce que, comme nous l'avons dit, les paralleles servent a mesurer l'hauteur du soleil et non son angle horaire.[3]

Note 1. This refers to the circles of altitude parallel to the horizon.

Note 2. As Sévère puts the winter tropic at 24° from the equator and the colatitude of the 4th climate is 54°, the altitude of the winter tropic is 30°.

Note 3. Word for word "latitude" and "longitude"; but here there is no question of ecliptic latitude and longitude. La latitude qui s'observe et qui est rapportee au sud droit, est la hauteur. La longitude qui se compte sur le bord exterieur est certainement

L'angle horaire se mesure de l'orient à l'occident de 0° à 360°. Ces degrés sont gravés sur le bord de l'enveloppe, c'est-à-dire de la tablette exterieure qui renferme toutes les autres. These 360° are divided into 4 quadrants; the origin of these quadrants is on the meridian (south).

(P. 96) Thus the whole sphere is *doubly divided* by the *parallels of altitude* and *horary angles;* the same division regulates the movement of all the spheres and all the stars. This knowledge is necessary for the climates and five zones. Le philosophe imagina de graver pour chaque climat, sur les tablettes dont nous avons parlé, la *hauteur* qui va du sud au nord, puis décrire *la longitude* qui va de l'est à l'ouest,[1] et la meme sur le bord de la tablette exterieure comme nous l'avons dit plus haut.[2] Il enseigna ensuite comment on peut connaitre les deux a la fois par la rotation de l'araignee et (d'un index) qui est fixé dessus comme nous l'apprendrons plns tard.

The "rising" and "setting" are designated by their names on the horizon. The mid-sky "ou le centre du milieu du ciel est determiné par la ligne qui va de haut en bas, coupe à angle droit tous les parelleles, passe au 90° degré et s'appele le meridien," as we have said. Il est evident qu'en partent de ce 90^e degré du côté où les paralleles se coupent tous sur cette meridienne, nous aurons le côté sud;

(P. 97) et de ce méme 90^e degré vers la partie opposée où s'arretent les paralleles nous aurons le coté north. *The part*

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l'angle horaire. On remarquera cependant qu'il est toujours question de la hauteur meridienne. On peut donc, des que l'on connait la latitude du lieu d'observation, en deduire immediatement la declinaison. C'est la sans doute ce qui permet à notre auteur de confondre quelque fois hauteur et declinaison.

Note 1. *Ce doit etre l'azimuth qui se compte sur l'horizon.* (*I strongly doubt this; there is nothing said about azimuths throughout the book.* MPK.)

Note 2. Sur le bord de la tablette exterieure se mesure certainment l'angle horaire, distinct de l'azimuth; Sévère designe tous les angles dièdres (azimuth, angle horaire et longitude) par le meme mot.

where the hours are marked is said to be under the earth and the meridian line which passes there is called "centre de dessous la terre", or "des pères"; the rising is called "centre de vie" and setting "centre de noces".[1] The three circles drawn on the tablet for all climates above and below the earth are called "tropiques"; that at the extremity of the tablet and which bears the commencement of Capricorn ♑ is called "tropique d'hiver"; that in the middle which bears the commencement of ♈ (Aries) and ♎ (Libra) is called "tropique equinoxial"; the interior circle on which the commencement of ♋ (cancer) moves is called "tropique d'ete".

One should remember that all the circles figured on the astrolabe by the philosopher like those of the tropical zones, the meridian, the parallels, all the four centres and les huit lieux que l'on distingue entre eux,[2] les horizons des sept climats l'axe ('axon) and the two poles, the circle of the middle of the Zodiac, the Artic and the Antartic circles situated above and below the earth (p. 98) and many other analogous things must be perceived by the spirit and do not fall under the senses. Hence the philosopher figured them in the air under the sphere of heaven.

I have said enough about the quadrant on the exterior tablet (the back), the dioptre, the parallels, the latitude and right ascension of the whole sphere, the meridian and that which is under the earth, the tropical zones; none of these things are objects of sense.

I add some remarks about the *spider*.[3]

It is above all the tablets; one can turn it, make it ascend to the Zenith, then (p. 99) make it descend to the setting and under the earth. On the quadrant on which are 90° (the back) one sees (p. 101) in what degree is the end of the dioptre called "index".

Note 1. They are the four pivots of the Arabs according to Sédilliot p. 96.

Note 2. They are the 12 houses. Sédillot and Firm Mat. See problem IX below.

Note 3. Letronne's remark in the Journal des Savants 1840–41 is wrong; "M. Ideler conjecture avec beaucoup d'apparence de raison qu'il sagit d'un quadrant horizontal, ainsi nommé a cause des nombreuses lignes partant du style vertical comme centre et figurant une toile d'araingée".

One looks for the same degree among the parallels of the climate, and then one learns what one wants to know. I will now go to the rules.

Page 238–273–Syriac Text of Part II.
" 274–303–French translation of the same.

USES OF THE ASTROLABE.

I. (p. 274): To find the solar hour during the day; then the ascendant (degré qui se leve) for that hour, the degree of the setting, that which is in mid-heaven, and that under the earth.[1]

Get from the tables the true place of the sun. Then turn the instrument so that a ray passes along the dioptre from hole to hole. We note the degree where the index is. Then we turn round the Astrolabe, then turn the spider till the degree of the sun comes over the parallel of the same degree (of altitude) which we have observed. (p. 275) Then we look at the degree under the earth diametrically opposed to the sun and in what hour it is. That is the hour we look for. The degree and sign on the eastern horizon is "that of life", opposite on the western horizon that of marriages (aux noces), that which has the highest elevation, *i.e.* on the meridian is "milieu du ciel", and that diametrically opposite "aux pères."

Example, in 4th climate; altitude 30°, ☉ 0° ♋; (p. 276) turn the spider and put 0° ♋ on 30° altitude; then 0° ♑ will be in the 3rd hour which is the hour of the day. Thus also we find easily the 4 centres. Asc. 5° ♌ (Leo), Desc. 5° ♒ (Aquarius), At 6, 24° ♈ (Aries) and under the earth 24° ♎ (Libra). "Pour connaitre les ascensions[2] depuis le commencement du Bélier jusqu'au point qui se leve a cette heure, nous regardons où se trouve l'index de l'araignée, qui est le commencement du Capricorne, puis nous comptons les degres depui le milieu du ciel (le méridien) jusqu'au point ou se trouve le commencement du Capricorne, et nous trouvons 112 degres pour ces ascensions dans le quatrième climat. Nous trouvons

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Note 1. The problem is similarly put and solved by Macarius Hieromonachus (Rhein Mus. t. VI, p. 159).

Note 2. Cf. infra IX.

aussi que le Lion se leve et que le Verseau se couche (p. 277) dans le 5° degré. Quand nous portons ce nombre sur la sphere droite, (this is somewhat doubtful – MPK) nous trouvons que le Bélier est au milieu du ciel dans le 24° degré; il est evident que la Balance est sous la terre dans le meme degré." From the 1st to the 6th hour, the sun is on the parallels which precede midday (le milieu du jour); from the 6th to the 12, it is on the parallels which follow midday. *One knows whether the sun is before or after midday by the Index; if the degrees shown by the Index increase,* the sun is mounting to midday; if they decrease, the sun is descending après le milieu du ciel. Similarly with a star.

II. Find the hour at night by the aid of the stars.

Take altitude of star by dioptre; then turn the star (*i.e.*, on the spider) on to the altitude; find the place of the sun that day on the spider, and the hour in which that place is, is the nocturnal hour. From this the centres can be found.

III. Find the hour at night by the aid the moon.

First find the place of the moon (in the tables); find its altitude; turn the spider and put the true place of the moon on the parallel of the same altitude; then find the place of the sun on the spider; it will show the hours passed.

IV. To find the epoché *i.e.*, the station of the sun by the astrolabe.

Take the sun's altitude from time to time beginning a little before the 6th hour; when the altitude ceases to increase it is midday; turn the spider until a degree of the Zodiac coincides with the parallel of that altitude (on the meridian); that is the place of the sun. But one must know the season, so that the point may be found in one of the three signs corresponding to the season. (The wording is peculiar "et le degré du Zodiaque, que nous voyons coincider avec un certain nombre de l'intersection intérieure de ces paralleles, egal au degré observé a l'aide de la dioptre quand le rayon du soleil le traversait, nous fait connaitre dans quel signe et dans quel degré se trouve le soleil pour ce jour-la. Nous disons que le soleil est dans ce degrê et dans signe qui le contient).

V. To find the (epoque) *i.e.* the station of the moon and fixed planets with the help of the astrolabe.

Take the altitude of a star marked on the spider (et cherchons sur le quadrant quel est son degré). Then turn the spider so that the star coincides with that parallel of altitude (Nous tournons l' araignée jusqu'a ce que l'etoile arrive sur le meme degré de l'intersection interieure des paralleles; nous fixons alors l'araignée dans cette position). Then find the altitude of the moon (en quel degré se trouve la lune); then find on the parallel the same number as that given by dioptre; le signe et le degré qui correspondent a l'intersection du parallele egal un degré de la dioptre nous donnent la position de la lune pour cette nuit (ou plutot; le degré du Zodiaque qui a meme hauteur).

VI. Trouver les changements d'ascension et de descente, c'est-à-dire la latitude de la lune.[1]

Nous cherchons comme d'habitude, l'heure nocturne a l'aide des etoiles fixes; puis nous cherchons, soigneusement, comme nous l'avons dit.[2]

(This passage has been misunderstood. It really refers to Rule 3, by which the time is determined by the moon; a phrase "and we determine therefrom the hours" is missing MPK), les degrés (p. 281) de la lune[3]. Si les deux temps sont egaux, nous disons que la lune est au lieu des eclipses, c'est-à-dire, dans le (plan) diamétral du Zodiaque. Si le temps donné par les étoiles est moindre que le temps donné par la lune et que celle-ci soit au méridien, nous disons que la lune est au nord de l'ecliptique. Si le temps donné par les etioles est plus grand que le temps donné par la lune[4] et que celle-ci ne soit pas encore arrivée au meridien

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Note 1. Mot a mot; "les retrogradations". Mais il ne sagirait alors que de trouver le maximum et le minimum de la latitude de la lune, tandis que le demonstration semble donner le sens de la latitude a une époque quelconque.

Note 2. Cf. Chapitre V.

Note 3. C'est-à-dire le degré du Zodiaque qui a meme hauteur.

Note 4. Le parallelisme semble demander ici le membre de phrase "nous disons que la lune est au sud de l'ecliptique".

ce sera l'inverse; si le temps donné par les etoiles est moindre, nous disons que la lune est au sud de l'ecliptique; si le temps donné par les etoiles est plus grand nous disons que la lune est au nord de l'ecliptique, c'est-à-dire au nord du plan qui passe au milieu de la Zone du Zodiaque.

VII. Verifier si l'astrolabe est bien ou mal construit, ce premier degré du Bélier.

Put 1° ♈ (Aries) at the eastern horizon; then the spider-index should be in mid-heaven; turn the spider till 1° ♎ (Libra) is at the eastern horizon; the spider index must have moved 180° with this one side; (some words like "take any other degree of the Zodiac" seem wanting—MPK). Apres cela multiplions par 12 heures le nombre des temps d'une heure qui est ecrit en face du premier degré du Bélier sur la troisième table pour le quatrième climat dans le canon donné par Ptolémée, et ajoutons le nombre des ascensions placé en face du degré du soleil pour ce meme quatrième climat, dans la seconde table. Si le nombre tiré du canon est égal au nombre donné par l'index de l'araignée, l'astrolabe est bon; sil y a une difference de deux ou trois degrés on voit par cette methode que l'astrolabe est mauvais.[1]

(Note 1—Il s'agit de valuer directement les ascensions d'un certain nombre de signes, puis de comparer ce nombre donné par l'astrolabe a celui qui donné une table construite par Ptolémée, dit l'auteur, et analogue sans doute a celles que l'on trouve dans l'Almagests au livre II, chapt. VII).[2]

(Note 2—"Les temps d'une heure" sont les degrés de l'equateur qui correspondent a une heure, on les obtient en divisant par douze l'arc d'equateur compris entre les points du lever et du coucher du soleil.)

Nous pouvons le savoir aussi à l'aide du canon fait par Ptolémée pour la sphère droite. En effet, la quantité dont s'est eloigné l'index de l'araignée, depuis le degré ou le signe du milieu du ciel est égal au nombre *des levers sur la sphère droite* de ce degré du milieu du ciel. Nous pouvons connaitre (p. 283) cela pour un signe et un degré quelconque. Et quand nous cherchons ainsi les levers d'un signe quelconque et les levers de la sphére droite, il est evident que si nous faisons tourner l'araignée jusqu'au point diamétralement opposé à celui que nous cherchons, et si nous regardons en meme temps de combien l'index de l'araignée s'eloigne du milieu du ciel, puis que nous comparions le canon a l'astrolabe, et que nous ne trouvions pas le méme nombre, nous devrons en conclure que le canon ou bien l'astrolabe est mal fait, et nous controlerons les deux car le cannon de Ptolémée est fait d'apres l'astrolabe. (There is some confusion in the language, although the purport can be guessed—MPK).

VIII. Comment on pourra verifier si l'index est exact et bien construit.

Find the place of the sun; turn the spider and put that place on the meridian (and mark its altitude); about the sixth hour take the altitude of the sun (from time to time) till it does not increase; if this observed altitude is the same as that derived from the astrolabe the index is correct.

(Note—that the word altitude is nowhere used in the text: it is "le nombre indiquē par l'index de la dioptre" and "le nombre obtenu quand nous avons amené le soleil au milieu du ceil."-MPK).

(P. 284.) IX. Comment, a l'aide de tout l'astrolabe, on peut connaitre quelles sont les ascensions[1] de chaque signe dans un climat quelconque, soit au centre de vie, soit a celui du milieu du ciel, et quelles sont les "descentes"[2] au centre "des noces" et a celui qui est sous la terre.[3]

(Note 1—On appelle ascensions (anaphoroi) au centre de vie (sur l'horizon est) qui correspondent à un signe, le nombre des degres de l'equateur qui montent au dessus de l'horizon, pendant que ce signe lui-meme monte tout entier au-dessus de l'horizon (Cf. Ptolémée L. II, sect., c. VII et Bar Hébréus Cours d'astronomie L. II. ch. III sect., 1,2,3,4). Le movement de l'araignée reproduit le mouvement diurne; les degrés de l'equateur sont notés sur le bord de l'astrolabe. Voir au ch. 1 en note, le triangle a résoudre pour trouver les ascensions.

(Note 2- Kataphoroi par opposition aux ascensions anaphoroi.

(Note 3– Signification of the 4 centres; also called pivots translation of cardines (geniturarum). These intervals were each divided into three, the 12 Loci of Firmicus II, XVII, or the 12 houses of Séverus as each lodges a sign and some planet. The first place ([illegible]) begins at the horizon and goes down to the 30th degree below the horizon. The 4th [illegible] begins at the inferior meridian. The 7th [illegible] at the west horizon, the 10th [illegible] at the superior meridian Mesomanéma.)

Mark the number of degrees the index (l'indicateur des degrés de l'araignée, qui se trouve sur les degrés d'ascension) has moved from the time the beginning of the sign was at the eastern horizon to the time when its end was there; these are the *numbers of its ascensions for the climate.*

Similarly for the meridian; we make the whole sign pass and mark the degrees passed by the index. (Nous opérons encore de même sur la sphère droite...Nous plaçons alors au milieu du ciel le commencement du signe *et cetera.*

Similarly the "descents" for the 4th and 10th houses are found.

(P. 287.) X. To find the number of ascensions from 0° ♈ to the horoscope.

Put the horoscope on the eastern horizon; the number of degrees moved by the index (which is at the commencement of the Capricorn) from the mid-heaven is the number required. One finds the same in the second column of Ptolemy against the degree of the horoscope. These are also to be found in the table for the right sphere.

(Note–One finds the ascensions in the Almageste L. II, ch. VIII for every 10° for various climates).

XI. Comment on peut connaitre a l'aide de l'astrolabe (p. 388) la composition des heures du jour ou de la nuit, ou la longuer et ou brievetė du jour et de la nuit qui nous occupent,[1] c'est-à-dire (la plus ou moins grande distance) du degre "de vie" ou du degré "des noces".

(Note 1 – 2 sorts of hours—(i) *temporal*, Hōras Kairikas, 12 from sunrise to sunset and so longer or shorter according to season; (ii) *equinoctial* hours corresponding to 15° of the equator; the days contain more or less of them according to season. Bar Hebreus II ch. V, sec. 1).

Put the sun (on that particular day) on the eastern horizon and then on the western; the number of degrees the index has moved in the interval divided by 15 gives the hours (equinoctial), and the same divided by 12 gives the "degrees of an hour" (temporal).

(P. 289) If we want the night hours put first on the horizon the degree diametrically opposed to the sun; and turn the spider till this degree reaches the western horizon. Then the number of degrees moved by the index divided by 15 gives the equinoctial hours of the night; divide the same by 12 and we have the degrees of an hour". (Here the word equinoctial is in the text itself.-MPK).

The hours of the night may also be found by deducting those of the day from 24 and vice versa; and the degrees of an hour by night, by deducting from 30 those for an hour of the day and *vice versa*. (Note—This is *unique*).

(*No. XII* seems wanting—MPK).

(P. 290) XIII. Comment on peut connaitre à l'aide le l'astrolabe quelle est la plus boreale et la plus australe de deux villes cansiderées.

Take the altitude (hauteur) of the sun at 6 hours (midday), when it is in the first degree of Aries in both places; that in which the altitude is greater is to the North. This may be done even when the sun is in any other sign, or it may be done with any of the fixed stars. Here the word "*hauteur*" *is used in several places in the text itself.*

(P. 291.) The same may be done by measuring the shadow of a style of iron, reed, wood or any other material in both places at midday on the same day of the same month. The one with the longer shadow is to the north.

(P. 292.) XIV. Comment on peut connaitre la longitude d'une ville par rapport à une autre; quelles est la plus orientale and quelle est la plus occidentale.

We find with the astrolabe the mid-heaven (*i.e.* the degree of the Zodiac on the meridian) in both places during an eclipse at the same phase, *viz.*, when it begins, ends or during it. The one with the greater number is more to the east.

XV. Comment on peut trouver la difference des midis dans deux villes.

Deduct the degrees of the dioptre (really that of the mid-heaven which has been deduced from the altitude in the last problem) of one from the other and divide by 15;

(P. 293) the number obtained represents the equinoctial hours. Thus when it is three hours at Carthage, it is 6 hours at Arabella. Really the longitude of Arbelles is 80° and carthage 35°.[1]

(Note 1—These longitudes are from l'ile de Fer and are a bit exaggerated. They also reckoned longitudes from the continent 10° to the east of the ile de Fer (Bar Hebreus II, chap. 1, Sec. 1) that explains why the longitude of Cairo was 55° as asserted by Mariol (Marcel?) whereas it was 65° according to Sédillot).

XVI. Comment on peut chercher les ascensions de la sphere droite dont a ecrit Ptolémée.

Multiply by 6 the degrees of an hour of the particular sign and degree we desire the ascensions of which are written opposite the latter (in Ptolemy's table). Add to those the number of the ascensions written against the same sign in the same climate in the second table. The total is the ascensions required. *e.g.* for the 1° ♋ (Cancer) in the 4th climate the degrees of an hour are 18° 7′: multiplied by 6 this gives 108° 42′: to these add the ascensions, viz. 72° 22′[1]; then we get for the right sphere 180°[2] for the first degree of Cancer.

(Note 1- These figures, *i.e.* 72° 22′ would seem to correspond to the latitude of Hellespont in Halma's Ptolemy p. 106.

(Note 2- Really the sum is 181° 4′).

(This seems 90° too much unless this that it is taken from 0° ♑ (Capricorn).

XVII. Comment on peut connaître en quel climat on est, a l'aide du soleil ou de l'une des etoiles fixes.

Take the altitude of the sun at midday, and put the spider on each of the climates in succession; that in which the degree of the sun (taken from the tables) is at the meridian on a circle of the same altitude is the climate in question. (Si le degré du soleil coupe sur le méridien le *circle de hauteur correspondant* au nombre indiqué par l'index nous disons que nous sommes dans le troisieme climat et cet.).

(P. 295.) XVIII. Comment on peut trouver *la latitude* des sept climats.

La latitude commence au sud sur la sphere droite (l'équateur); elle est donc divisee en 90 degrés c'est ā-dire la moitie des 180 degrés qui sont au-dessus de l'horizon du ciel. Nous tournons l'arraignée dans chacum des climats jusqu'à ce que le premier degre du Bélier soit au meridien. Nous lisons alors le degré ecrit sur les paralleles du mileu du ciel (le degré de hauteur) qui correspond au premier du Bélier, puis nous le retrenchons de 90° et nous disons que le reste est la latitude du climat qui nous occupe a partir du sud (de l'equateur).

(Note—Marcarius Hieromonachus (Rhein Mus. p. 159) gives the rule, viz. finding the latitude from the midday altitude of the sun when it is in the 1st degree of Aries. This does not require the astrolabe, but only the dioptre).

XIX. Comment on peut connaître, a l'aide de l'astrolabe, la longitude et la latitude des etoiles fixes.

(*P. 296.*) Pour connaitre la latitude des etoiles fixes[1] on fait tourner l'arraignée jusqu'a ce que l'etoile qui nous occupe arrive sur le côté sud du meridien. On regarde alors de combien de degrés de latitude cette etoile est distante de la zone du zodiaque vers le nord ou vers le sud. Pour la longitude……

(Il manque ici un feuillet).

Note 1 - Il ne sagit encore que des etoiles figurées sur l'astrolabe elles sont en petit nombre, une trentaine au plus. Cf. Sedillot, p. 167. Really this is giving the polar latitude —MPK).

XX and XXI (Part of the XXIst proposition is lost and it begins).

......chacune de ces e'toiles fixes, et quelle est sa distance en latitude jusqu'aux etoiles fixes, a l'aide de l'astrolabe.

Pour la latitude nous tournons l'araignee, comme nous l'avons dit plus haut, jusque ce que l'etoile qui nous occupe se trouve au milieu du ciel; puis nous regardons sur quelles parallèles se trouvent et la zone du zodiaque et l'etoile qui nous occupe. Nous prenons la distance des zones du zodiaque aux étoiles et obtenons ainsi celle de notre etoile a la zone du zodique soit au sud soit au nord. (This seems to be a repetition of Rule XIX.—MPK). De la meme maniere, en nous servant toujours du zodiaque et en plaçant (l'etoile) sur l'horizon est, nous trouvons sur *quel degré de la longuer de la zone* et avec quel signe se leve cette etoile. (This seems to give the longitude of the point of the ecliptic rising with the star, or oblique longitude—MPK). Nous trouvons en plus par ce moyen si l'etoile apparrait[1] a l'orient ou a l'occident du soleil. Une etoile est visible quand elle est à 25° à l'est ou à l'ouest du soleil.

XXII. To find the *inclination* of each sign of the Zodiac upon the equator[2] to north and south for each climate, and in what places are the tropical zones.

Put 0° ♈ (aries) on lower meridian; that gives the position of the equator, it being the degree of the parallel on which 0° ♈ is. Then put 0° ♋ (Cancer) on lower meridian; (Here ♋ seems to be a mistake for ♑) deduct its parallel from that of the equator, that is the inclination of Cancer upon the

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Note 1– sur ܦܣܝܣ Cf. Bar Hebreus, p. 77.

Note 2– I believe it is a question of *declination* which Bar Hebreus calls [illegible] ܡܢ [illegible] (cours d'astronomie p. 17-18).

equator on the south, *i.e.* la zone d'hiver viz. 24°. Similarly 0° ♋ gives 24° to north for the zone "d'été". Similarly one finds to the south 0° ♑ for the zone "de l'hiver". One does the same about the sun.

(Note–24° for the obliquity was found by Eudemus being the side of a polygon of 15 sides, Letronne 1840-41. Jean Philoponus also takes the obliquity to be 24°).

(P. 298). XXIII. Comment on peut trouver l'inclinaison du soleil sur l'equateur au nord et au sud dans tout signe et dans tout degre.

Put sun on meridian; the difference between its parallel and that of the equator is the inclination (really declination) of the sun.

(P. 299). XXIV. De la mesure en latitude de la demi-sphere, c'est-à-dire des 180 degré qui s'etend du nord au sud. Division et distances relative des diverses zones.

(P. 300) (A) Measure from 0° ♋ (Cancer) the "Summer zone" to 90° (the zenith) in the 4th climate; the distance is 12°. (Note–the latitude of the 4th climate is 36° N and the obliquity 24°).

From the equator to the 90° parallel (zenith) is 36°.

From the 90° (zenith) to the winter zone which is 0°♑ (Capricorn) is 60°, and to the zone du sud appellé "antartique" it is 90°.

(Hence the Antartic zone is 72° in diameter round the south Pole, being just invisible from the 4th climate).

From the north extremity of the zone called Arctic, which is always visible, to the point that is the centre, *i.e.*, the north pole which passes through the north end of the axis (of the world), is 36°.

From the centre (*i.e.* north pole) upto the south end (*i.e.* of the arctic zone) is still 36°.

From the zone always visible to the middle of heaven is 18°.

These last three make up 90°. (P. 301). From the zenith to the zone always hidden is 90° and so altogether these are 180°.

P. 301. (B) Another division into 5 zones made by the philosopher:

(1) "Artic", 36° from the north pole. (2) Tropique d'été is of 30°. (3) Tropique equatorial 48° *i.e.* (24°) to the north and (24°) to the south of the equator. (4) Tropique d'hiver 30°. (5) Antartique 36°. Total 180°.

(C) Another division by Ptolemy. (1) Arctic 36° 9′. (2) Summer zone 30°. (3) Equatorial zone 23° 51′ to the north and as much to the south of the equator (4) Winter zone 30°. (5) Antartic zone 36° 9′.

Les poles sont des points ou des positions sur lesquels on conçoit que sont situées les deux extremites (p. 302) de l'axe, que l'on imagine méné obliquement du haut en bas, c'est-à-dire du nord au sud, en passant directement au milieu du centre de la terre, qui est aussi placé egalement au milieu de la sphère.

XXV. How to find "the ascensions" of the sign in the east (that of life) and that in mid-heaven.

We first take the ascensions of the degree of life (*i.e.* ascendant) as stated before (No. IX) First we put the degree on the eastern horizon, and mark the degree indicated by the index; then turn the spider till the whole sign is above the horizon; note the degrees marked by the index; deduct the smaller from the larger and the difference is "les ascensions de ce signe, et de la même manière son pouvoir sur le nombre des années[1].

En operant jusqu'au milieu du ciel nous trouvons combien un signe met d'heures font aller au milieu du ciel, parce que les divers signes ne montent pas de la même maniére au dessus de l'horizon est et a la position de la sphère droite. Par example, (P. 303) lorsque dans le quartième climat, nous prenons les ascensions des degres des levers, comme on l'a vu précédemment on regarde ensuite de combien de degrés a avancé l'indicateur des degrés de l'araignée; puis on tourne l'araignée jusqu'à ce que le degré de vie soit sur le meridien et on regarde de combien de degrés a avancé l'indicateur des degrés de l'araignée, on retranche les degrés de vie des degrés du milieu du ciel, et dans le reste on trouve les degrés d'une heure[1] pour le point de vie.

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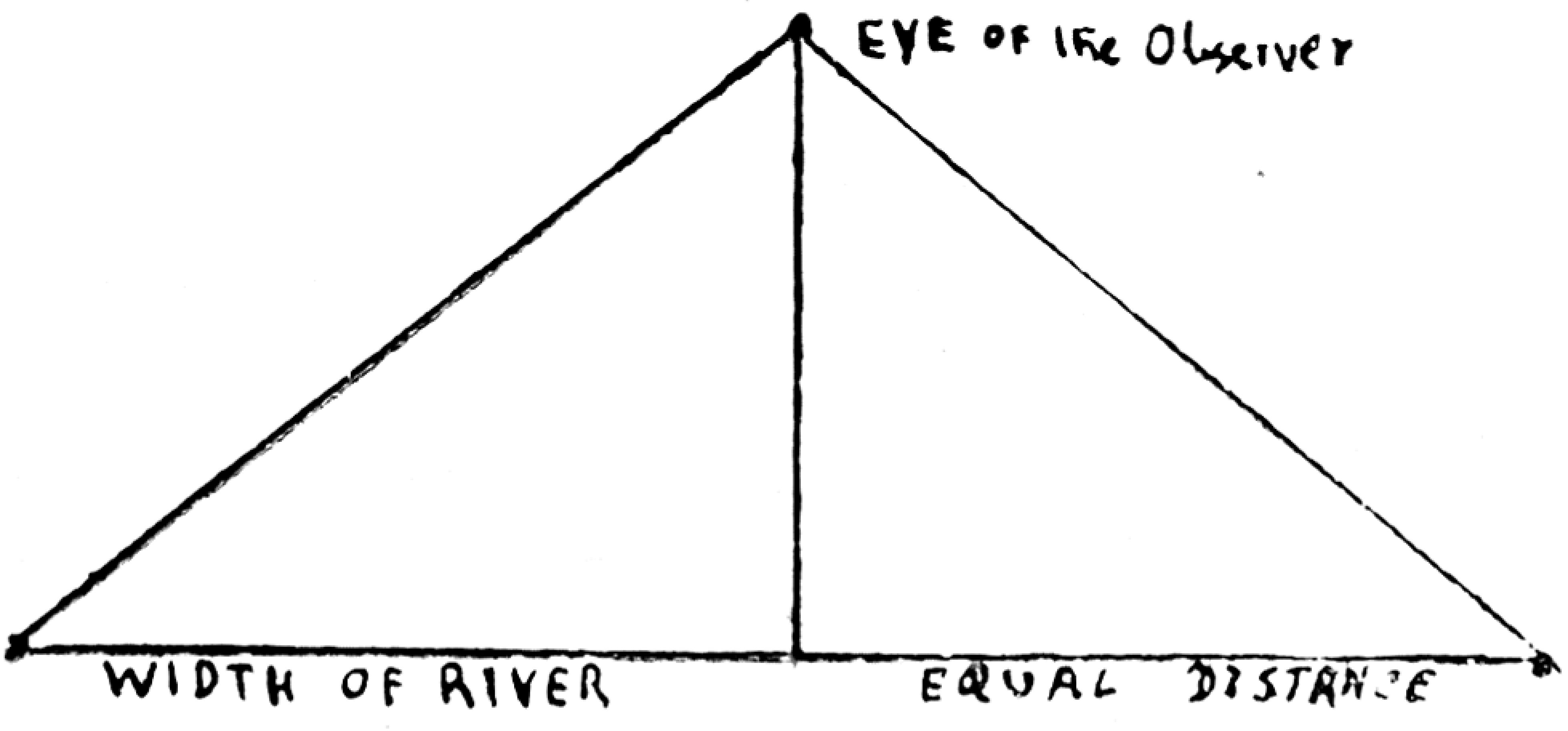
[1] -Cf. Fisur Met. II. XXV. De distributione temporum.

[The twenty-five sections as given above, clearly show the variety of uses for which Astrolabe can be employed. Albīrūnī, in his Tfhm. (vide pp. 300-315, of the recently edited Persian Edition) has given in addition to these some trigonometrical problems. There are also special books giving full details of the various uses for which Astrolabe can be employed. One such particular book by Khājah Naṣir-ud-din Tūsi is 'Bīst Bāb-i-Asṭarlāb' (بیست باب اسطرلاب). A commentary on this book is also written by Abd-ul 'Aly Birjandi, giving additional information on the uses of the Astrolabe.

It will not be out of place to show how Astrolabe is used for simple Trigonometrical problems as under.—The passages quoted are from Albīrūnī. Both Arabic and Persian texts contain them.

XXVI. To find the breadth of a river or of a piece of ground, the other extremity of which is inaccessible.

Stand on the bank; hang the astrolabe in the right hand and move the dioptre till you sight the other bank: then turn round without changing your position and without altering the sight-rule; look through both sights for a mark which you can recognize and measure the distance between your position and the observed mark; the breadth of river is the same as this distance.



XXVII. To find the depth of a well.

Stand on the margin of the well with the Astrolabe in the

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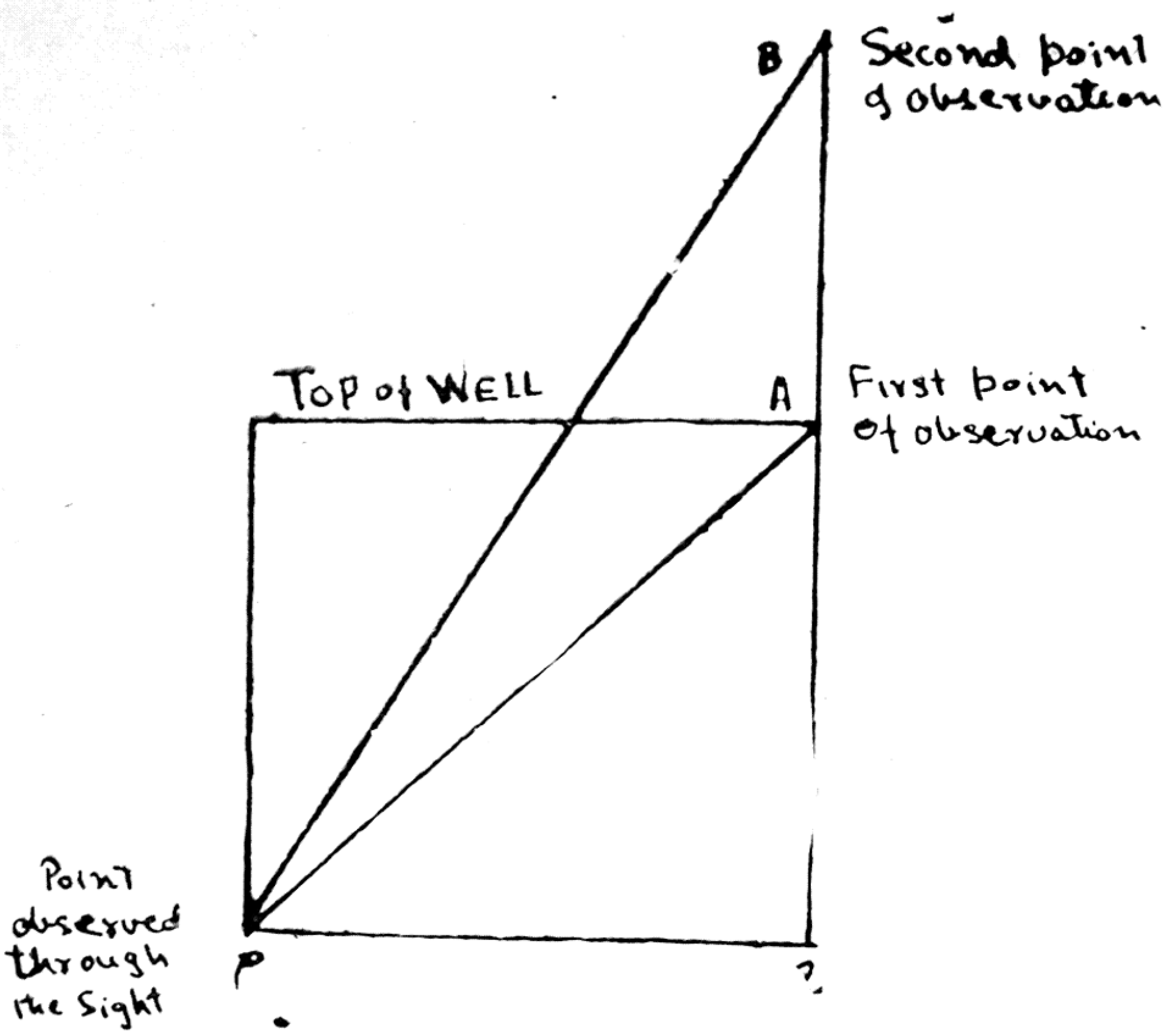
[1] -voir XI.

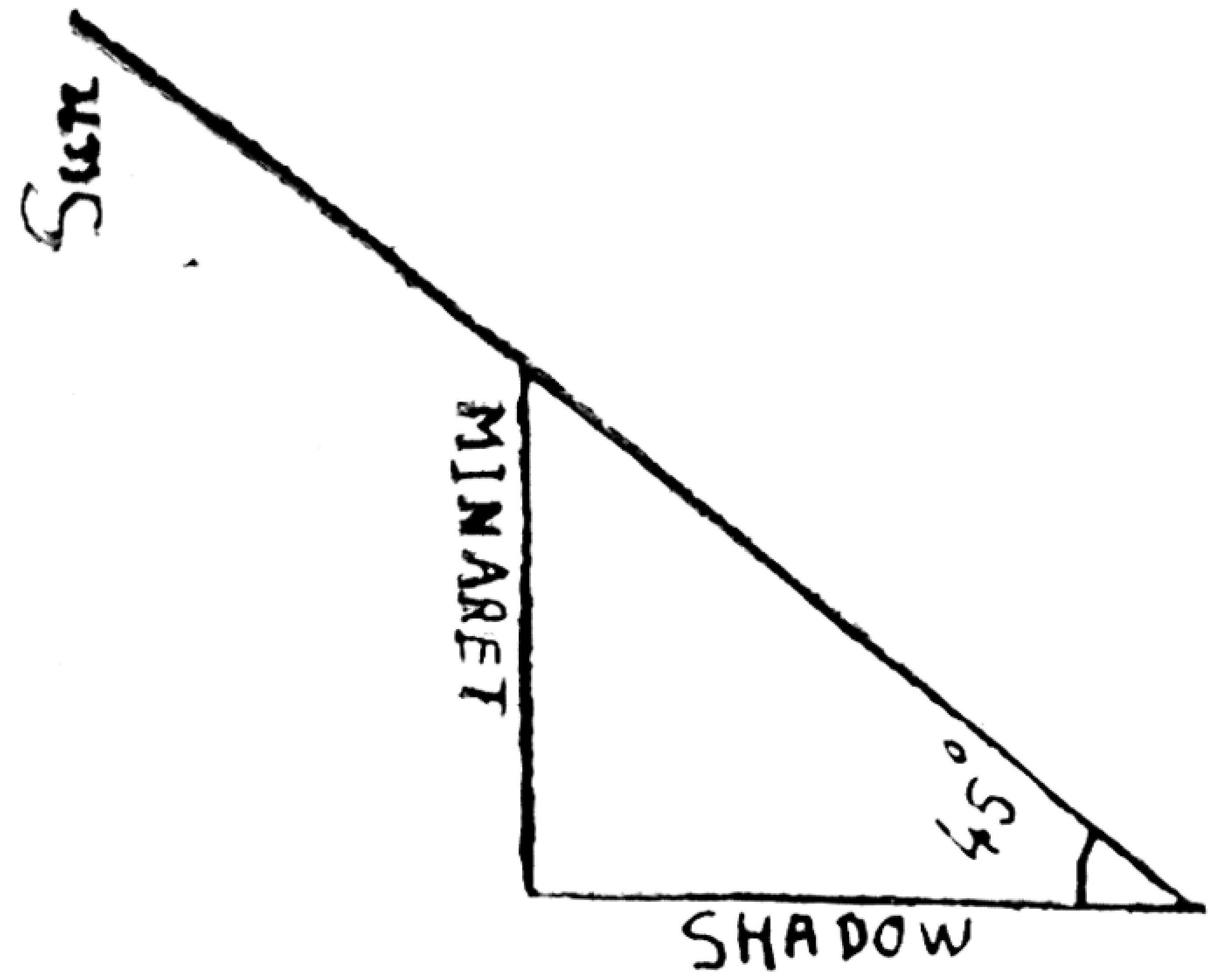

B
Second point of observation
TOP of WELL
A
First point of observation
Point observed through the Sight
P
?

left hand, the quadrant of the altitude towards you and move the sight-rule till the opposite margin of the water or the bottom is seen through both the sights. Then note the number (x) of fingers in the quadrant of shadow to which the rule points: again place the tip of the rule at one finger less *i.e.* x−1, and go straight up higher until the opposite margin is again sighted without disturbing the position of the rule. Measure the distance k between these two points of observation, and multiply it by the number of fingers of shadow noted at the 2nd observation *i.e.* x−1 and the result $(r-1)\,k$ is the depth of the well; whilst that distance (the last result) multiplied by 12, gives the diameter[1] of the well.

(Note 1–There is obviously some mistake here; both the Arabic and Persian editions give this; but actually the distance multiplied by $\frac{12}{x}$ is the diameter of the well.

XXVIII. To find the height of a minaret or wall the base of which it is not possible to reach.

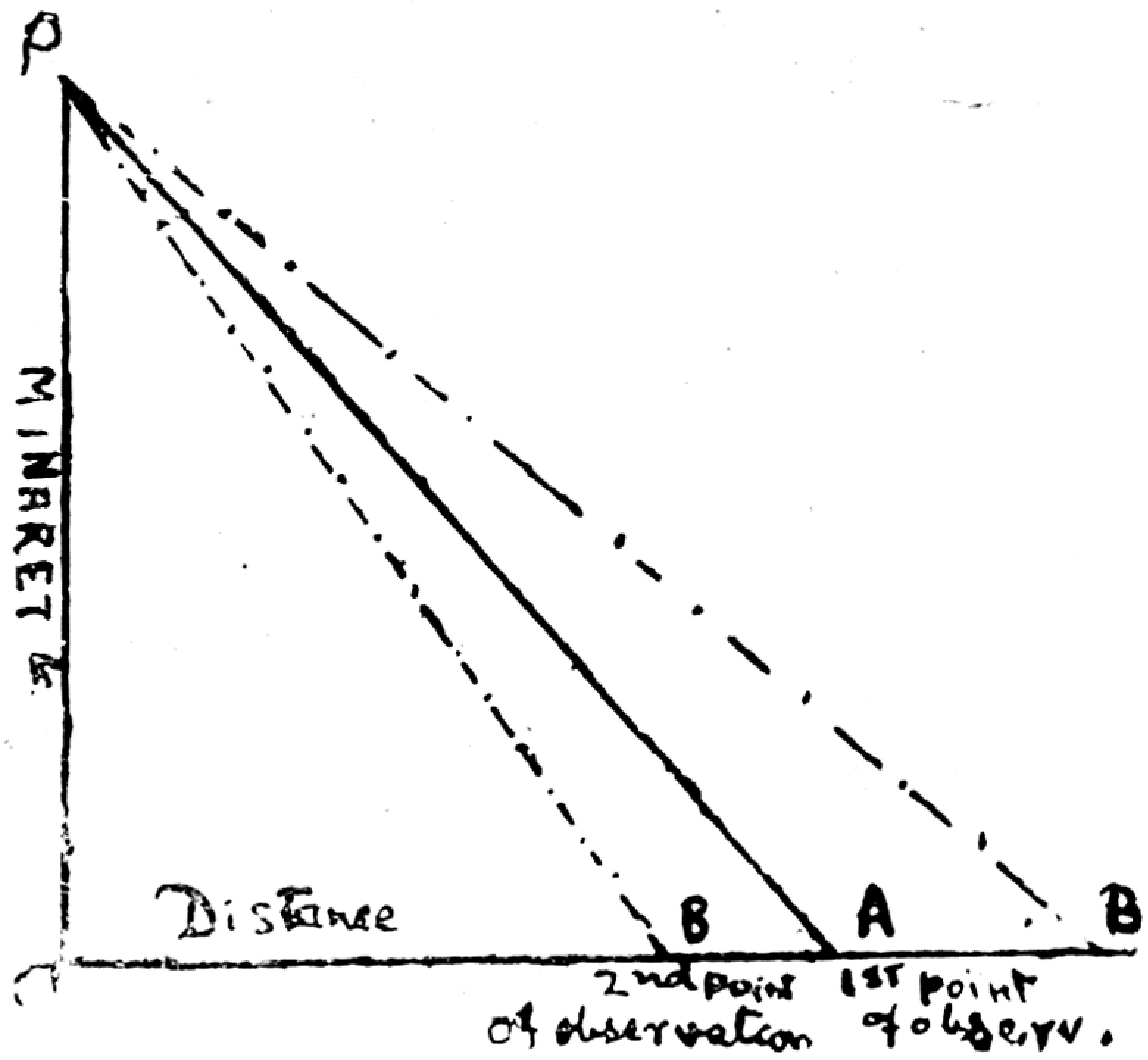
Take the altitude of the sun, and continue observation till it attains 45°, then measure the shadow: this gives the height of the minaret. If the sun does not reach 45°, at the desired time, place the point of the rule at 45°, and move forwards and backwards till you find a point where the top of the minaret is sighted, then measure from that point to the base of the minaret and



add your own height; the result is the height of the minaret.

XXIX. To find the height of a minaret, column or mountain the base of which it is impossible to reach.

Stand where you are and move the rule until you see the top of the object through both sights just as you take the altitude of a star; then note the number (x) of fingers in the quadrant of shadow to which it points and move forwards and backwards (according as the ground is most level); if forward, place the rule-point at one finger less *i.e.* x−1, if backwards at one finger more *i.e.* x+1 and walk till the top is again visible through both sights. The distance between the two points of observation multiplied by 12 is the height of the mountain, while the same distance multiplied by the number of fingers of shadow observed at the first point of observation gives the distance between that point and the base of the object. Similarly the height of any object in the air, such as a bird or a cloud which is so stationary as to allow of the altitude being taken from two different points, can be determined by the same method as well as the distance between you and a perpendicular dropped to the ground from the object.]



NOTES FROM THE ENCYCLOPÆDIA OF ISLAM

BY

Houtsma, Arnold, Basset and Hartmann.

(Vol. I, A.D. 1913. London. Luzac & Co. D X=C=109).

ASTROLOGY by C. A. Nallino

ث = *th* , ج = dj , چ = ch, ح = ḥ , خ = *kh* , ذ = *dh*
ش = *sh* , ص = ṣ, ض = ḍ , ط = ṭ , ظ = ẓ , ع = ʻ
غ = *gh* , ق = ḳ or q,
ء (Hamza) = ʼ e.g. الرأس al-ra'ṣ, طالع = tāliʻ

Name :

Technical name of *Astrology* is ʻilm علم (or ṣinaʻat صنعة) aḥkām al-nudjūm (or ḳaḍāya ʻlnudjūm) *i.e.* “the science (or art) of the decrees of the stars”, or shorter, ʻilm (ṣināʼat) al-aḥkām. Some Arab writers from the 13th cent. A.D. on, also use the expression ʻilm al-nadjāma. On the other hand the expression علم النجوم or صناعت النجوم “science or (art) of the star” علم النجوم or علم التنجيم denote both *Astronomy or astrology or both*. The *Astrologer* is called al-ḥakāmī الحكامى or munadjdjam منجم but the latter also denotes the Astronomer. Not till the 19th century is there any precise distinction between the Munadjdjim منجم “astrologer”, and Falaki فلكى “astronomer”.

Branch of Natural Science :

Astrology is considered, following Aristotle by the authors of encyclopaedias, one of the 7 or 9 branches furūʼ (فروع) of the “natural sciences” (ʻulūm ṭabiʻīya) علوم طبيعية placing it with “medicine, physiognomy, alchemy, interpretation of dreams, etc.” Both astronomers and astrologers and other savants (*e.g.* al-Fārābī, the I*kh*wan al-ṣafaʼ and Ibn *Kh*aldūn), following Ptolemy consider it a branch of “the science of the stars”, which is one of the 4 great divisions of the “mathematical sciences”, (ʻulūm riyāḍiya) علوم رياضية

First Principles :

Astrology based on the principle that all the changes in the sublunary world—the Aristotelian “generation and corruption”—(genesis kai phthora, al-kawn waʼlfasād) are connected with the nature and motions of the heavenly bodies. Man as microcosm is subject to the influences (tā'*th*īrāt) تأثيرات of the stars; according to Ptolemy they are physical forces and tend to make the *patient* (قابل Ḳābíl) similar to the *agent* (فاعل fā'il); according to the Muslims, the stars are not real agents, but mere indicators (dalā'il, دلائل)—Influences numerous and contradictory; hence task of weighing them is arduous.

Imaginary Bodies or Places & Divisions of the Sign:

Not only real celestial bodies, but places having only a theoretical existence are supposed to have influence. Such are, "the head" (al-rā's الرأس) and "the tail'' (al-*dh*anab الزنب); signs of the Zodiac singly or in group of three according to the four "*trigons*" (mu*th*alla*th*āt مثلثات' triplicates); so also certain sub-divisions unknown to the Ptolemaic astrology, such as the "*Decans*" (wu*dj*ūh وجوه' facies), the third part of a sign, and the Novenaries 1/9th of a sign (Nuhbaharāt or Nawbahrāt نوبهرات) the degrees of the Zodiac "*masculine*", (Mu*d*-*h*akkara مزكره') "*feminine*" (mū'anna*tha* مؤنثه), *shining* (muḍī'a مضيه'or munīra منيره' lucidi), *dark* (muẓlima مظلمه'), *coloured* (mutalawwina متلونه'), *smoky* (ḳatima قطمه or mud*kh*ina مدخنه' fumosi), *void* (khāliya خاليه), *wells* (ab'ār ابار gradus puteales), *increasers of happiness* (Zā'ida fī 'l-sa'āda, زائده فی السعاده) *etc.* There are also parts and points of the Zodiac of importance from their relation to the sun, moon and five planets, for they are their *limits* (hudūd حدود' termini, fixes), *houses* (buyūt بيوت' domus, domicilia) and *injuries* (wabālāt وبالات detrimenta), *exaltations* (ashrāf اشراف exaltationes principatus, altitudines), and *falls* (hubūṭāt' هبوطات' casus, dejectiones).

Horizon & Meridian Angles:

The horizon and the meridian also play a great part; their points of intersection with the ecliptic are called the *four pivots* (awtād اوتاد anguli, centra, cardines): (1) the *ascendant* (ṭāli' طالع); (2) the *pivot of the earth* (watad al-arḍ, وتد الارض al-rābi' الرابع angulus terrae, imum coelum); (3) the *descendant* (watad al-*gh*ārib وتدالغارب al-sābi' السابع angulus occidentalis, occidens, occasus); (4) the *culminating point* (wasaṭ al-samā' وسطالسما al-'ās*h*ir العاشر medium coelum) - The arcs of the ecliptic contained between these pivots are each divided into three equal parts by means of circles of declination (which pass through the poles of the equator); the ecliptic is thus divided into 12 sections called the 12 celestial houses (buyūt

Houses—بيوت' houses), which form the basis of every astrological calculation.

Aspects

Relative positions of planets; 5 principal combinations; (1) the *conjunction* (kirān قران or mukārana مقارنه' but as respects the conjunction of the sun and moon idjtimaʿ اجتما and the four aspects (anẓār انظار aspectus) or applications (ittiṣālāt اتصالات) *viz.* (1) *opposition* (istikbāl استقبال); (2) *sextile* (tasdīs تسديس); (3) *quadrature* (tarbīʿ تربيع); (4) *trine* (ta*th*lī*th* تثليث). "If about a planet as centre a circle be described with a radius of 60°, 90°, or 120°, the two points of intersection of the ecliptic with the circle, and also the trigonometrical process of calculating them are called

Projectio Radiorum

"projectio radiorum" (maṭraḥ al-*sh*uʿā مطرح الشعاع).

Those astrologers who adhere most closely to the Ptolemaic tradition do not take these five combinations into account; but all the rest add many others (Ibn Hibinta reckona 24), which are called *status* (ḥālāt حالات) *planetarum ad invicem.*

Parts—Lots or *Partes* (sihām, سهام sing. sahm سهم) imaginary ascendants reckoned on the ecliptic at a certain distance from the true ascendant. Ptolemy and his Arab followers admit only one, the "*pars fortunae*" (sahm al-saʿāda, سهم السعاده Ho kleros tis tuchis), but other astrologers admit a very large number, which amounts in the Introductorium of Abū Maʿ*sh*ar to 97 exclusive of about 30 other "partes" mentioned by al-Ḳabīṣī. [vide Al-Bīrūnī, Tfhm. pp. 437-460.]

The geographical element not to be omitted.

Systems: (1) Questions (2) Elections.

Such is the *equipment* its usage also complicated. Three principal systems: (1) that of *Interrogationes* or Quaestiones masā,il مسائل erotiseis); (2) that of *Electiones* (ikhtiyārāt اختيارات katarchai), *i.e.*, the choice of the auspicious moment for accomplishing such and such an act; this moment is determined by observing in which of the 12 celestial houses the moon is. Astrologers who preferred the Indian methods employed the 28 lunar stations (manāzil منازل قمر) in placec of the 12 houses.

“*Revolutiones*”—(3) *Genethlialogical*, based on “revolutiones annorum” (taḥāwīl al-sinīn تحاويل السنين). Its fundamental principle is that the configuration at instant of birth fixes the destiny. The tropical years are reckoned from birth, cr the accession of a sovereign, or foundation of a town, sect, **or** religion, etc. This Ptolemy's system, who has little to say about Electiones and nothing about Quaestiones. For individuals were used *Revolutiones annorum nativitatum* (tahawēl sini'l-mawālid تحاويل سني المواليد); for prognostications concerning people, towns, sects etc., (and consequently epidemics, famines, wars, inundations, etc.), *Revolutiones annorum mundi* (tahāwil sini 'l-'ālam تحاويل سني العالم).

Ascendant—First operation is to find the ascendant, from which the initials of the other 11 houses were found (اوائل awā'il or marākiz مراكز). As the exact instant of birth is difficult to determine, there are rules for finding it; such as the “animodar”

Numūdār—(numūdār نمودار); the methods commonly used are those of Ptolemy, Hermes and Zoroaster. “For prognostications not concerning individuals the ascendant of the eclipses or of the great planetary conjunctions were employed.”

Destiny is also determined by one of the planets (including the sun, the moon, the ascendant and pars fortunāē) occupying one of the 5 places called by Ptolemy “*topoi apheticoi*”, by the mediaeval astrologer “*loci hilegiales*” (mawādi'al-hailādj مواضع الهيلاج).

Indicators—The planet then becomes apheta or indicator (dalil دليل, or haila*dj* هيلاج significator, alhylech, hilegium, aphetis), which is to be *directed* towards the stars and those points in the heavens possessing a particular astrological signification.

Directiones—This *directing* on its mathematical side (tasyīr تسيير atazir, directisi aphesis); calculate the hour-angle that the object directed has to turn to come to the circle of position (circle passing through the north and south points and the apheta or indicator) of the apheta; each degree of such motion counts as a solar year in the nativityof an individual, and as a day for general events. For prognostications relative to

Other Indicators

peoples, towns, religions, etc., the Arab followers of Ptolemy chose as Indicator the planet or star possessing most "dignities" over the point of the ecliptic where there has occurred an eclipse of the sun or moon. But the majority give preference to the system of the planetary conjuctions (ḳirānāt) which they probably learned from the Indians; they base their calculations on the conjunctions ot the three superior planets, Mars, Jupiter, Saturn. The *tasyīr* of the ascendant gives the duration of life. For other purposes other indicators have to be chosen.

Perfectio

Further it is necessary to translate into terms of time according to special rules, the uniform movements of the indicators according to the order of the signs (*i.e.* from west to east), in order to determine species of lords for the tropical solar years, the months, and the days of life; this movement (of the indicator) or the point of the ecliptic where it arrives, is called intihā' انتهاء (alynthie, profectio).

Fardārāt

Finally, there are cycles of the years of life, which are specially subject to the influence of this or that planet; these cycles, corresponding fundamentally to the planetary "rulers of time" (chronocratores) of the Greeks, but modified however and often very complicated (especially in Abu Ma'shar), are called fardārāt (fridariae) فردارات

Secondary Systems:

(1) Decans (2) Trines

Other secondry methods, such as (1) that of the constellations and images (suwar صُوَر) ascending with the *decans*, which goes back to the Chaldean tradition of Teucer, and (2) that which is founded on the risings of the star Sirius, (Egyptian Sothis) and only employed by the Musalmans of Egypt.

History

Muslim astrology derived from various sources; Ptolemy, Vettius Valens, Dorotheus, Sidonius Teucer, Antiochus and several pseudepigraphical treatises; also from Pahlvi and Indian books, and from the traditions of Egypt, Syria and Mesopotamia. Hence most have adopted all 3 systems; the completest mixture being the books of Abū Ma‘*sh*ar. What distinguishes the Muslim Astrologers from their predecessors is the *perfection of the mathematical processes.* Astrology condemned by theologians, jurists and philosophers; (exceptions: Al-Kindi, the I*kh*wān al-Ṣafā’ and F*kh*r al-Din al-Rāzi), still in practical life greatly prevalent even at the courts of the caliphs. Even now in Yemen the Ḳāḍis are astrologers. The mathematical processes of astrology are generally dealt with in the works of astronomy.

Judicial Texts Printed

The "judicial" side (aḥkām احكام) dealt with in many treatises; only two unimportant ones edited, viz.—

(1) Introduction of Abū Ma‘shar in Boll, Sphaera, 1903 (2) al-Kindi on the duration and fortunes of Islam (in O. Loth al-Kindi als Astrolog, in Morgenlandisches Forschungen. Fleischer Festschrift, Leipzig, 1875 p. 263-309). The following works translated in the Middle Ages may be mentioned:

Books Translated into Latin & Printed

(1) Commentary of Haly Heben Rodān (Ali b. Riḍwān) on the Quadripartitum (Tetrabiblos); Commentary of Aḥmed b. Yūsuf called Ibn al-Dāya on the Centiloquium (Kartos, Kitāb al-*th*amra) wrongly attributed to Ptolemy, the two printed together in Venice in 1493 and 1519; (3) several works of Abū Ma‘*sh*ar; (4) treatise in 8 books of Albohazen Hāli filius Abenragel (Abu 'l-Hasan ‘Ali b. Abi 'l-Ri*dj*al), printed in Venice 1495, 1503, 1523, and with slight variation at Basle, 1551, 1571; (5) the convenient Liber Introductorius of Alcabitus (Al-Ḳabīṣī), several times printed, oftenest with the commentaries of Johannes de Saxonia, and annotated also by V. Nabod (Cologne 1560); (6) treatise of Zahel (Sahl b. Bi*sh*r) and of Messahallach (Mā Shā’Allāh) printed as appendix to Nos. 1 and 2 above. (7) Liber Nativitatum of Albubather (Abu Bakr Al-Hasan b. al-*Kh*aṣīb), printed in Venice 1492 and 1501; (8) De judiciis nativitatum of Albohāli (Abu ‘Ali Yaḥyā 'l-*Kh*aiyāt), Nurnberg 1546 and 1549; (9) De nativitatibus and De interrogationibus of Omar (Md. b. Omar b. al-Farru*kh*ān al-Ṭabri)

Venice 1503 and as appendix to Firmicus Maternus, Basle 1533 and 1551.

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(1) Its sources and polemics s. v. Star, Encyclopaedia of Religion and Ethics of Hastings ;

(2) Some Mathematical processes and terms in Nallino's Commentary on al-Battāni sive Albatenii, Opus Astronomicum, Milan, 1899-1907, 3 vols.;

(3) For technical terms, see also – (a) Mafātiḥ al-'ulūm (ed. van Vloten). (b) Dictionary of the Technical Terms used by the Musulmans (ed. Sprenger); (c) Dieterici, Dii Propadeutik der Araber (Berlin 1865) — all unsatisfactory – . For theory of planetary conjunctions see—

(4) O. Loth, in the Monograph on Al-Kindi cited above;

(5) Ibn *Kh*aldūn خلدون , Prolegomenes, (Transl. of De Slane, ii. 217-226). For the life and works of the Astrologers:

(6) H. Sūter, Die Mathematiker und Astronomer der Araber (Leipzig, 1900 = Abhand. z. Gesch. der mathem. Wissenschaften, x. Heft; with the important Nachtrage in Abh. z. Gesch. d. math. Wiss., xiv. 1902, 137-185)--

(7) The astronomical works mentioned at the end of this article.

ASTRONOMY

Name

‘ilm al-hai’a علم الهيئة (science of the aspect of sun-rise) or ‘ilm al-aflāk علم الافلاك (‘science of the celestial spheres). For other names, see Astrology. Al-Fārābi and Ibn Rushd (Averrhoes) call theoretical astronomy صناعت النجوم التعليميه (sinā‘at al-nu*dj*ūm al-ta‘līmīya) and "experimental art of the stars" (sinā‘at al-Nu*dj*ūm al-tadjrībīya – صناعت النجوم التجريبيه)-- one of the 4 mathem. sciences. Spherical astronomy, *i.e.* the study of the apparent movements of the stars, and theory of instruments. The study of meteors in the Aristotelian sense (including comets, shooting stars, etc.) and of what might be called Astro-Physics and Celestial Mechanics (origin of celestial movements, nature of the spheres, light of the stars, *etc.*) belongs entirely to the domain of physics and metaphysics. The total knowledge wanted for calculating the hours of the day and night, especially with a view to fixing the times af the 5 canonical prayers is called ‘ilm al-mīkāt or ‘ilm al-mawākīt علم الميقات - علم المواقيت "science of the fixed time."

In the beginning of Islam, Arabs had some practical knowledge; they were guided in their journeys by the brightest stars and moon, whose places of rising and setting they knew and from which they could approximately tell the time by night; seasons determined from the moon's position among the 28 manāzil al-ḳamar منازل القمر lunar mansions. Among the settled tribes the agricultural seasons and meteorological prognostications were associated with the annual rising of certain stars, cosmic setting of (naw' نوء) of the lunar stations.

Indian Sources.

Scientific study in the 2nd cent. Hijri (8 cent. Chr.) begun under the influence of 2 Indian books, viz. (1) ब्रह्मस्फुट सिद्धान्त Brahamasphuṭasiddhānta of Brahmagupta written in 628 A. D. brought to Baghdad in 154 H. (771 A. D.) and used as model by Ibrahim b. Ḥabīb al-Fazarī and Ya‘ḳūb b. Ṭariḳ, (2) the works of आर्यभट Āryabhaṭa called (al-Ar*dj*abhad or al-atdjabhar) composed in 500 A.D. from which Abū-l-Ḥasan al-Ahwāzī derived his tables of the planetary movements. These books consisted of short introductory texts followed by numerous tables of celestial movements arranged according to the artificial millennial cycles, based on the hypothesis of the conjunction of all the heavenly bodies at intervals of millions of years. This method called "al-sindhind" السندهند corruption of सिद्धान्त *siddhānta*) was still employed by Muslim astronomers at the end of the 5th Cent. Hijri (11th cent. A. D.). From Indian books the Muslim also learned the use of trigonometrical Sines).

Persian Sources–

To these selections from Indian Books there was soon added the Arabic translation of the Pahlavi tables entitled Zik-i-*Sh*atro-ayār, royal astronomical tables". (Arab. Zī*dj* al-Shāh or Zī*dj* al-*Sh*ahriyār) which had been compiled in the last period of the empire of the Sassanians. They had great vogue with the Muslims of the IX. century A. D. but about 2 centuries later they ceased to be used.

Greek Sources.

The Greek influence was last in order of time but first in order of importance; it introduced into Muslim astronomy the geometrical representation of the celestial movement, so characteristic of the Hellenic genius. First translation (not very satisfactory) of the Al-Magest dates from the 8th or the beginning of the 9th century; it was followed by two other much superior, that of al-Ḥa*dj*d*jā*d*j* b. Maṭar (الحجّاج بن مطر) finished in 212 H. (827-8 A. D.), (not in 214 as commonly stated), and that of Ḥunain b. Is*h*āk (حنين بن اِشاق) after the middle of the 9th century, revised by Thābit b. Ḳurra (ثابت بن قرّة). In the first half of 9th century were also translated—the Geography, the Hand-Tables, the Planetary Hypotheses and the Planisphere of Ptolemy; the Hand-Tables of Theon of Alexandria; the work of Aristarchus on the distance of the sun and moon; two treatises of Autolycus, 3 of Theodosius, and one of Hypsicles. In the same century probably appeared the translation of the tables of Ammonius and the translation of a work entitled Kitab al-man*sh*ūrāt (كتاب المنشورات) wrongly ascribed to Ptoleny, dealing with the size and distance of the celestial bodies.

Observatories

at Gondē Shāpur (near Kazroon) —

First series of regular observations with fairly accurate instruments seem to have been made at *Dj*undaisābur (Gondē Shāpur in the S. W. of Persia) in the first years of the 9th century and was utilised by Aḥmed al-Nahāwandī, when compiling his General Tables (al-Zidj al-mu*sh*tamil) (الزيج المشتمل): But it was during the Caliphate of Al-Māmūn (813-33 A. D.) that the most brilliant period of Muslim astronomy commenced.

at Alshamasīya

At the Obseavatory in the quarter al-*Sh*amasīya of Baghdad astronomers under Yaḥyā b. Abi Manṣūr (d. 830 or 831 A. D.) made systematic observations and "verified with remarkably precise results all the fundamental elements of the Almagest; the obliquity of the ecliptic, the precession of the equinoxes, the length of the solar year, *et cet.* After these observations they composed the celebrated "Verified Tables" (al-*zīdj* al-mumtaḥan الزيج الممتحن) for which they had also at their disposal the observations at Mt. Ḳāsiyān قاسیان 2 or 2½ miles to the north of Damascus. Al-Māmun measured the arc of the meridian between Tadmur (Palmyra) and al-Raḳḳa (الرقة); he found a degree to be 56 2/3 Arabic miles, a remarkably accurate value; for an Arabic mile is equal to 6473 ft. and thus a degree comes to 366,842 ft., a number which exceeds the real value between 38° and 36° N. Lat. by 2877 feet only. (See Nallino: Il valore metrico del grado di meridiano secondo i geografi arabi – Turin, 1893) — Among the calculators of that time was Md. b. Mūsa 'l-Khwārizmī, الخوارزمی whose *zīdj* had a wide circulation during 2 centuries.

at Bāb-al Tāk

From 850-870 observation at their own house near Bāb al-Ṭāk on the Tigris in Baghdad by the sons of Mūsā b. Shākir.

at Shiraz

Other observations in the 2nd half of the 9th century at *Sh*irāz, Naisābūr and Samarḳand; al-Battani (q. v.) observed from 877 to 918 A. D. at al-Raḳḳa on the Euphrates. Thābit b. Ḳurra (d. 288 H= 901 A.D.) utilized previous observations for revising the theory of the movement of the sun; al-Māhāni and al-Nairīzī continued systematic study of the heavens. Shortly after 300 H. (912-13 A. D.) Ḥaba*sh* composed at Baghdad his principal work in which trigonometrical processes attained an unexpected degree of perfection."— In the 2nd half of the 10th century the Būyid-Sultāns founded an observatory at their own palace and gathered around them astronomers including ʻAbd al-Raḥmān al-Ṣūfi (d. 376=996), Ibn al-Aʻlam (375=998), Wīdjan b. Rustam al-Kūhī, Aḥmed al-Sāghānī (d. 379=990), Abuʻl-Wafā, (d. 388=998) and various others.

Al-Birūni at Ghazni

At Ghazni in Eastern Afghānistān, al-Birūni (d. 440 = 1048), the most original and the profoundest thinker that Islam has produced in the domain of the physical and mathematical sciences, displayed the greater part of his literary activity.

Egypt

In Egypt scientific study of astronomy began under the Fāṭimid al-ʻAzīz (365-86 = 975-96 A. D.), founder of observatory which received rich endowment from al-Ḥākim (386-411 = 996-1021 A. D.). Here Ibn Yūnus (d. 399 = 1009) made from 367 (977) to 398 (1007) the observations on which is based his "al-zīj al-Ḥākimī". Among the writers comes Ibn al-Hai*th*am (d. 430 =1039) author of a very popular little manual, wherein obviously on the analogy of the second book of the Hypotheses of Ptolemy, he explains the celestial movements by the two hypotheses of solid spheres and discs (manā*sh*ir مناشير) of the sphere, *i.e.* segments passing through the centre of the shpere.

Observatory in Spain

In Spain astronomy cultivated from the middle of the 10th cent. A.D., encouraged by the princes of Cordova, Seville, and Toledo; and the works that appeared in Spanish and afterwards in Latin under Alphonso X of Castille (1252-1282) are due to Arab Astronomy. The most distinguished Spanish astronomers were—Maslam al-Ma*dj*rīṭī (d. 398 = 1007-8 A.D.), Ibn al-Samḥ (d. 426 = 1038), *Dj*ābir b. Aflah (d. between 1140 and 1150 A.D.) called 'Geber filius Afflae', and especially Al-Zarḳālī (Arzachel) in the 2nd half of the 11th century. It was in Spain that the philosophers opposed the Ptolemaic representations of the celestial movements.

North Africa

In North Africa no recognised observatories, but Abū'Ali al-Ḥasan al-Marrāku*sh*ī (wrongly called Abū'l-Ḥasan'Ali in some MSS.) who wrote in Morocco about 1250 A.D.

Observatory at Rai or Naisābūr:

Around the Sel*dj*ūḳs of Persia a number of astronomers; at their disposal observatory at al-Raiy or at Naisābūr founded in 567 (1074-75) by Sultan Jalaluddin Malikshah, who also reformed the civil calendar. For one of his successors al-Khāzinī composed shortly after 512 (1118) his important "San*dj*aric Tables" (al-zij al-sandjari).

Observatory at Marāgha':

Hulākū in 657 (1259) began the building of the observatory at Marāgha' near Urmiya; with this were associated several astronomers chief of whom was—Naṣīr al-Dīn al-Ṭusī, who after 12 years work published his Īlkhānic Tables (al-zij al-īlkhānī). Kuṭb al-Dīn Md. al-*Sh*īrāzī (d. 710 = 1310) a pupil of Naṣīr al-Din also deserves mention.

Observatory at Cairo:

In Cairo Ibn al-*Sh*āṭir (d. 777 = 1375-79) took observations and his Tables were renowned in Syria, Egypt and all N. Africa.

Observatory at Samarkand—

The astronomical science of the Mussalmans experienced its last glories at Samarḳand. Ulū*gh* Beg, Djamshīd al-Kāshī, Ḳaḍī Zāde, al-Rūmī, 'Ali al-Kūshdjī, carried out direct observations. The tables of Ulū*gh* Beg are famous and were in use for centuries. U.B. himself wrote a preface in Persian a few months before his assasination (853 = 1449). After U.B. "only authors of elementary manuals, compilers of Ephemerides and Almanacs and describers of the commonest instruments;" the real astronomers have disappeared and in their place we find only the muwaḳḳit مُوَقِّت' of the mosques.

Muslim Astronomy—

They (Musulmān Astronomers) accepted the fundamental features of the Ptolemaic system; earth fixed; motions of all celestial bodies circular and uniform, and their apparent inequalities are explained by a combination of circles concentric (muma*thth*ila ممثلة) with the zodiac, eccentric circles (kharidjat al-marākiz خرجة المراكز) and epicycles (aflāk tadāwir افلاک تداویر). Even in the 4th Century A. H. the question of the revolution of the earth round its axis is discussed; but in the following centuries its absolute immobility is universally accepted. The nature of the spheres (aflāk) is only discussed by the theologians and philosophers, and the astronomers of the first centuries are contented to consider them for the purpose of their science as geometric circles, and it is only in the time of Ibn al-Hai*th*am (d. 430=1039) that there is introduced into astronomical instruction the idea of solid and transparent spheres. No trace of heliocentric system. "It ought not to be forgotten that with us the question of the Copernican system was for more than a century a purely philosophical one, indifferent to the astronomy of observation which could not have contributed any decisive or important argument in support of it."

The Arabs knew well that theories were no good and observation and correction of Ptolemy's numbers were necessary. They perceived that the apogee of the sun is subject to the movements of the precession of the equinoxes; al-Zarḳāli even discovered the slight motion peculiar to the apogee. They perceived that the obliquity of the ecliptic varied. Their determination of the elements of the sun, partly of the moon, lengths of the tropical and siderial years, account of precession are accurate. They improved the Planetary Tables. "In contrast to the Greeks they gave to Venus the same longitude of the apogee, the same eccentricity and the same centre of equation as to the sun, which was fundamentally equivalent to transforming the orbit of Venus in an epicycle of the solar orbit having the sun for centre, *i.e.* to making Venus a satellite of the sun." Their star catalogues have great importance; lastly on the application of trigonometrical formulæ, in the number and the quality of their instruments, and in the technique of their observations, the Arabs outstripped the Greeks. "In the number, continuity and precision of the observations we mark the most striking contrast between Greek and Muslim astronomy."

The hypothesis of the trepidation (ḥarakāt al-iḳbāl wa l idbār حركات الاقبال والادبار *i.e.* motion backwards and forwards) of the fixed stars which was accepted by *Th*ābit b. Ḳurra, and in a slightly different form by al-Zarḳāli is false. But it was advanced to explain variations in obliquity and precession. It is a mistake to attribute the discovery of the 3rd lunar inequality to Abū'l-Wafā; it was made by Tycho Brahe; but it must not be forgotten that about half of this "variation" was already contained in the prosneusis of Ptolemy and in the equation of the lunar anomaly (ta'dīl ḥāṣṣat (or *Kh*āṣṣat) al-ḳamar تعديل خاصة القمر) of the Muslim astronomers.

An eminent theologian, philosopher and astrologer, Fakhr al-Dīn al-Rāzī (d. 606 = 1210) exprsssed on several occasions his profound scepticism as respects fundamental hypotheses of the Astronomers. But it was in Spain that the Ptolemaic system was attacked, relying on Aristotle. The first to do so was Md. b. Yaḥyā b. al-Ṣāi'*gh* called Ibn Bā*d*j*d*j*ā*, the Avenplace of our writers (d. 533 = 1139) who rejected epicycles and claimed to explain by eccentric circles. Ibn Ṭufail (d. 581 = 1185-86) rejected both epicycles and eccentrics, but has not left his own views. Ibn Rushd or Averroes (d. 595 = 1159) largely revived Eudoxus Hypothesis of the concentric spheres, with its spiral shaped (lawlabī = hippopedi) planetary movements, *i.e.* in the form of an elongated ∞ according with the ecliptic, the one half ∽ being in the eastern and the other half ∾ in the western hemisphere; but he had no time to give a complete exposition of his system. Lastly, al-Biṭrū*dj*i (Alpetragius; d. 600 = 1204), "in order to reduce everything to harmony with the principles of the peripatetic Physics, not only admits, with Averroes, only spheres concentric with the earth and turning on different axes, but also makes another strange hypothesis (which he held in common with the I*kh*wān al-Ṣafa' and Fa*kh*r al-Dīn al-Rāzī) denying the existence of any motion of the celestial bodies from west to east; *i.e.* the direct movement (towards the east) of the planets is only an optical delusion, due to the fact that the angular celerity of the planets is less than the celerity with which the celestial sphere accomplishes its diurnal rotation round the earth. None of these hypotheses of the Spanish philosophers were accepted by the astronomers."

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AṢṬURLĀB OR AṢṬURLĀB

Greek astrolabes: Various instruments of 3 fundemental types : (1) "according as they represent projection of the celestial sphere on a plane, (2) or a projection of this projection on a straight line, (3) or the sphere itself without any projection."

(Completely copied). 1. The astrolabe in its stricter sense is the flat (saṭḥi سطحی or musaṭṭaḥ مسطح') Astrolabe or "A. planisphearum", in Arabic-dhāt al-ṣafā'iḥ ذات الصفائح (the instrument consisting of tablets). "It is a portable metal instrument in the form of a disc of from 3. 9″ to 7.8″ diameter, with a handle ('urwa عروه', ḥabs حبس) through which passes a suspending ring (ḥalḳa حلقه 'ilāḳa علاقه) by means of which it is suspended in a vertical position. The simplest type of of this astrolabe, and the one which was known to the Greeks and Syrians, consists of the following pieces :—

(a) the "mother" (umm امّ), a disc or circular tablet, with a raised edge (kuffa کوّفه, ḥadjra حجره, ṭawḳ طوق) which gives it the appearance of a box; it contains the other tablets. Its circular inner surface is called "face" (wadjih وجه), the exterior surface "back" (ẓahar ظهر) ; (b) other discs or circular tablets ṣufā'iḥ, صفائح, (sing. ṣafīḥa صفيح); usually nine in number, contained in the mother; (c) the "spider" ('ankabūt عنکبوت) or the "net" (*sh*abaka شبکه), a tablet placed above the others in the mother; it is made as open as possible having of course due regard to its solidity and the requisite space for marking in the signs of the Zodiac and the places and names of the chief stars; and in consequence consists only of strips of metal with seveal points or indicators (in the sing. shaṭba شطبه, shaẓiya شظيه) artistically cut which indicate the stars; (d) the ruler or diopter or alhidāde ('iḍāde عضاده) revolving round the centre of the "back" and as long as the diameter of the latter; its 2 arms are sharpened to a point (*sh*aṭba, shaẓīya) and each has a perforated sighting piece (libna لبنه, daffa دفّه, hadaf هدف) so that the sun's rays can pass through the two holes (thuḳba ثقبه) of the sighting pieces; the axis or pivot, "pole" miḥwar محوار ḳutb قطب') is a bolt which passes through the centre of all the other pieces and holds them together; the head of the bolt is to the back of the astrolabe, and at its other extremity there is a small bolt or screw-nut which prevents it from slipping out and from its form is called the "horse" (faras فرس).

On the back are several concentric circles and also chronological indications forming a sort of perpetual calender; they with the alhidāde are for measuring the elevation of stars. On tablets (b), stereographical polar projections of Almucantarāts (mukanṭarāt) *i.e.* circles parallel with the horizon, the projection of the vertical circles (dawā'ir al sumūt, circles of azimuths, دوائرالسموت), of the equator and of the ecliptic; for a particular geographical latitude in this projection the observer's eye is situated at one pole of the sphere and the plane of projection is tangential to the opposite pole and parallel to the plane of the equator. Certain astrolabes have also a tablet which gives for a particular geog. lat. the projection of the circles of position, of which, use is made in the astrological calculation called ' directio" (tasyīr); others have a table for all latitudes (li-*dj*ami' al-'urūḍ); also called the tablet of the horizons (safiḥa al-āfāḳīya) or general tablet (*dj*ami'ya جمعيه), the use of which is not very clear. According as the Almukantarāts of the tablets (b) are (i) all marked, or (ii) only from 2 to 2, (iii) from 3 to 3, (iv) from 5 to 5, (v) from 6 to 6, (vi) from 9 to 9, (vii) from 10 to 10 degrees, the astrolabe is called (i) tamm تم "complete", (ii) nisfi نصفى (bipartitum), (iii) *th*ul*th*ī ثلثى' (tripartitum), (iv) khumsī خمسى', (v) sudsī سدسى', (vi) tus'ī, تسعيه', (vii)'ushri عشرى'. Lastly this common flat astrolabe is distinguished into northern (*sh*amālī شمالى) or southern (*dj*anūbī جنوبى) according as the plane of projection is tangential to the north pole or to the south pole of the sphere; the former is naturally more common. By adding other markings to those already on the tablets and changing the order of the zodiacal signs on the net they obtained astrolabes which were at the same time northern and southern and were named after the somewhat fantastic figure in which the zodiacal signs were grouped on the net, as ṭabli طبلى "drum"; āsī آسى "Myrtle"; sarṭānī سرطانى or mūsarṭān مسرطان', "crab-"; sadfī صدفى "shell"; thawri ثورى, "Bull"; shakā'iki شقائقى "Anemone-Astrolabe", etc. Probably the astrolabe zawraḳī زورقى, "Boat-astrolabe" of Aḥmad al-Sidjzī (ca = 400 = 1009) belongs to this category. The "perfect" (kāmil كامل) astrolabe bore besides the other markings the circle of the sun's equation.

Other astrolabes with different projections are theoetical rather than practical; such as that devised by al-Biruni and called al-usṭuwānī الاسطوانى, "cylindrical ast." because of its projection (the

Analemma of Ptolemy), which al-Bīrūnī called cylindrical and we now call orthographic; the circles of the sphere are projected on this in the form of straight lines, circles and ellipses. The “مبطه’ mubaṭṭah (‘flattened”) astrolabe described by al-Biruni (Chronology p. 358-359), appears to have been only a stellar chart in equidistant polar projection, *i.e.* “the pole of the ecliptic was the centre of the projection, the parallels with the ecliptic or circles of longitude were represented by equidisant radii.

The Astrolabe gives on immediate observation the height of a star and consequently the hours already spent of day or night; it also enables one to solve without any calculation all the problems of spherical astronomy. It is useful further in geodetic operations, *e.g.*, for calculating the distance of an inaccessible place, the height of a building, the depth of a well whose diameter can be measured. Naturally we cannot look for absolute accuracy from so small an instrument, which moreover on account of the precession of the equinoxes and the diminution of the obliquity of the ecliptic is no longer of any use when a long period of years has elapsed since the period for which it was made.

As each tablet (b) is only good for a particular latitude, al-Zarḳālī (Arzachel) a Spanish Arab devised a tablet for general use; in it the projection is hoizontal instead of polar; eye at one of the equinoxes, and plane of projection (that of the solstitial colure, *i.e.* of the meridian passing through the solstitial points; “the projections of the 2 celestial hemispheres exactly coincide so that one sign suffices for both”. In its final form, which al-Zarḳālī called al-‘abbādiya in honour of al-Mu’tamid b. ‘Abbād, king of Seville (461 - 484 = 1068 - 1091). The entire instrument consists of a single tablet with two small subsidiary pieces. On the face of the tablet in stereographical horizontal projection the equator is represented with its parallels (madārāt) and its circles of declination (mamarrāt) and the ecliptic with its circles of latitude and longitude; not only then is the tablet valid for any geographical latitude, but also since the projections of the two hemispheres exactly coincide with the co-ordinates of the ecliptic and the principal stars, it replaces the net of the other astrolabes. A rod (ufḳ ma’il) oblique to horizon fixed at the centre of the graduated face fulfils the other functions of the tablet (b) of the common astrolabe; by inclining it more or less to the line of the equator we obtain the horizon of the place of observation, and can then deduce from its division the eastern and western amplitudes. On the back of the tablet are the alhidāde and the markings found on the back of the common astrolabe; but al-Zarḳāli further added the "circle of the moon", which enabled him to follow also the course of our satellite, and also a trigonometrical square which immediately supplied the "straight (horizontal) and inverted (vertical) shadows" (aẓlāl mabsūṭā wa mankūsa اظلال مبسوطه و منكوسه; co-tangents and tangents related to the radius divided into 12 parts) of the angles measured. This simple and perfected astrolabe was called by the other Arabs al-safīḥa al-Zarḳālia, "the tablet of al-Zarḳālī", and was famous in Europe under the name *Saphaea Arzachelis.* A variety of the instrument of al-Zarḳāli is the ṣafīḥa shakāzīya (or *sh*akāriya) about which we do not yet possess any accurate information." (vide fig. 19)

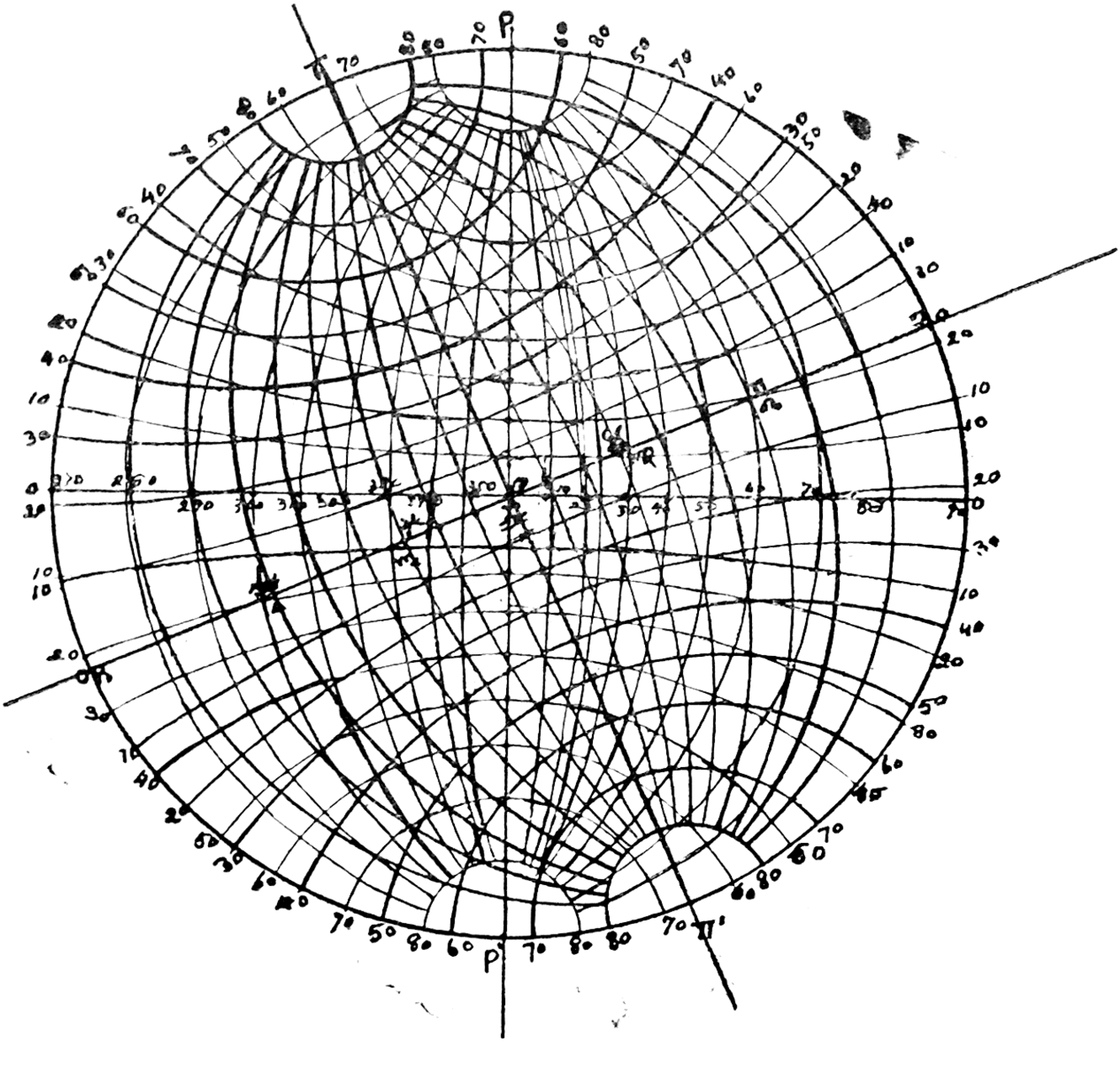

Fig. 19— The Tablet of Al-Zarqāli Astrolabe applicable to all Latitudes.

2. The linear (khaṭṭi) astrolabe, ʿasā 'l-Tūsīʿ, the rod of al-Tūsī, after its inventor al-Muzaffar b. Muzaffar al-Tusi (d. ca. 610 = 1213-14), resembles in form a calculating rod. The projection of the common planisphere astrolabe is projected on a straight line in the same plane: the instrument represents accordingly the intersection of the plane of the meridian with the plane of the projection of the planispheric astrolabe. Points marked on the rod indicate the straight or oblique ascensions, the divisions of the ecliptic, the almucantarāts, *etc.*; the threads attached to the rod are used for measuring the angles. The same operations can be performed with this instrument as with the flat astrolabe, but not with the same accuracy.

3. The spherical astrolabe (kuri, ukari), called "astrolabio redondo" in the Spanish works of King Alponso X. of Castille, exhibits without projection the diurnal movements of the sphere relatively to the horizon of the given place; it is of service therefore in measuring the heights of the stars, in determining the time, and in solving a number of problems in spherical astronomy. It consists of the following pieces: (a) a metal globe on which are marked the ecliptic, the horizon of the given place with its almucantarāts and its circles of height, the positions of the principal fixed stars, the division of the day into hours and equinoctial hours, the geographical latitudes of various places; (b) the "spider" or the "net" (ankbūt, *shabaka*), a metal hemisphere fitting closely round the globe and of such open work that it contains on the ecliptic (which forms its rim) the positions of the principal stars and half of the equator; (c) a small strip (safiha) of metal fitting closely to the surface of the net and with one extremity fastened to the equatorial pole, so that the other extremity is always on the equator; (d) a gnomon placed at right angles to the strip; (e) an axis passing through the globe, net and metal strip from one equatorial pole to the other.

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C. A. NALLINO.

MISCELLANEOUS

Mussalman Linear Measure

Woolhouse s - "Measures, Weights & Moneys".- 1890.

(*a*) Arabia At Mocha the long measures are the Guz (25 English inches), and the Cobido or Corid (19 inches). The Baryd (4 Farsakh) is 12 English miles.

(b) India

1. *Bengal*

3 Jows (barley- corns) = 1 unglee or finger = $\frac{3}{4}$ inch;
4 unglees = 1 Moot or hand = 3 inches;
3 hands = 1 span = 9 inches;
2 spans = 1 Haut or cubit = 18 inches;
2 cubits = 1 Guz or yard = 36 inches;
2 yards = 1 fathom = 6 feet;
1000 fathoms = 1 Bengal Coss or mile = 6000 ft.

2. *Madras*

The corid for cloth-measures is 18. 6 inches; but the English yard is generally used.

3. *Bombay*

16 Tussoos = 1 Hath = 18 inches;
24 Tussoos = 1 Guz = 27 inches.

(c) Egypt

4 Derahs make 1 Gasab = 2.832 English yards.

The principal measures for cloth and silk is the Pic (26. 8 English Inches).

(d) Ancient Measures

The natural cubit (24 Egyptian fingers) is 17· 71 inches;
The royal ,, (28 ,, ,,) is 20. 66 ,,

The Feddan al Risach or acre is 400 sq. Gasab = 3208 sq. yds. or ·6628 acres.

(e) Ottoman Asia, Aleppo, Smyrna, Etc.

The Turkish Pic (26.8 inches) is used for measures of length, and the Oke for weight. At Damascus the Pic is 23 inches.

(f) Persia

The royal Guerze, or Monkelser is 37$\frac{1}{2}$ English inches

(Kelly $37\frac{1}{5}$ inches = 419 Frenn lines).

The common Guerze is 2/3rds of the Royal or 25 inches (Kelly $24\frac{4}{5}$ inches = 279.6 F. L.)

The Arish is 38. 27 English inches (Kelly $38\frac{2}{7}$ inches = 431 F. L.)

(g) TRIPOLY (BARBARY).

The Turkish Dreah or Pik = 3 Palms = 26.42 English inches.
The Arabic Dreah or lesser Pic = 19. 03 English inches.

(h) TURKEY

The Pic or Pike is 26. 8 inches.

Extracts from LANE'S ARABIC LEXICON

s. v. صبع

As a measure ‘‘اصبع, signifies (a digit; *i.e.* a finger's breadth); the width of six moderate-sized barley corns. (Msb) voce ‘‘جريب ; the fourth part of the قبضة (Mgh & Msb ibid).

s. v. جريب و جرب

A certain measure (M, A, Mgh, K), or quantity of wheat (S, Msb) consisting of four اقفزة (pl of ‘‘قفيز) (M, A, Msb, K:) or ten اقفزة; each قفيز thereof consisting of ten أعشراء (pl. of ‘‘عشير); so that the عشير is the hundredth part of the whole: (TA:) or, as some say, a measure differing in different countries; as is the case of رطل and مد’ and ذراع etc (MF, TA). For the Pl. see what follows—Hence (Mgh) a certain quantity of land: (S, Mgh, Msb) as much as is sown with the measure of seed so called; (A, Mgh); like as mules and the space they travel are termed بريد (A, Mgh;*) it is sixty cubits by sixty cubits; according to Kudámeh, the extent termed أشل multiplied by itself; the اشل being sixty cubits; the cubit being six قبضات; and the قبضة, four اصابع; the 10th part of the جريب is called قفيز and the 10th of the قفيز is called عشير ; so that the قفيز is ten اعشراء: (Mgh:) it is a distinct portion of land, differing according to the different conventional usages of the people of different provinces; it is said that the width of six moderate-sized barley corns is called إصبع; قبضة is four اصابع ; the ذراع is six قبضات; ten أذرع are called قصبة ; ten قصبات are called اشل and the جريب is the extent termed اشل multiplied by itself ; the اشل multiplied by the قصبة is called قفيز ; and the اشل multiplied by the ذراع is called عشير; so that the جريب is ten thousand cubits; or according to Ḳudāmeh the Scribe, it is three thousand and six hundred cubits: (Mṣb) pl. (of pauc.) اجربه and (of mult.) جُرْبان' (Ṣ, Mṣb, Ḳ) and 'جُرُوب' (Ṛ, TA). See also جِرْبَة. Also a valley; (Lth, Mṣb, Ḳ;) (according to the second of which this is the primary signification); that is, in an absolute sense; and, with the article ال, the name of a particular valley in the territory of Ḳeys: (TA:) pl. أَجْرِبَة (Lth, TA).

s. v. ذراع ، ذرع

of a man (Mṣb), (the part) from the elbow to the extremities of the fingers; (Mgh, Mṣb); the forearm; syn. ساعد (q.v.; this corresponding to ساق of the leg (Lth, Ḳ:) and (the space) from the extremity of the elbow to the extremity of the middle finger: (M, Mgh, Ḳ:) [in the last of which the space is plainly shown to be meant, like as the part is shown in the Msb to be meant in explanation cited above from that work and the Mgh: see also جَرِيب]): in both these senses, sometimes masc., (Ḳ) according to Kh: (TA:) J says, (TA,) as relating to the arm, it is masc. and fem. (Ṣ, TA:) but Sb says it is fem.; (Mṭr says) it...... (about the gender) ...... the measure, thus called (*i.e.* the cubit) (Mṣb,) the ذِرَاعٌ مُكَسَّرَة (or cubit which is divided into fractions) (Mgh,) is six قَبَضَات (or fists) (Mgh Mṣb) of middling measure; (Mṣb) and this is called ذِرَاعُ العَامَّه or ذراع العامّه (the cubit of the common people, or the common cubit) because it wants one قبضة (or fist) of what is called ذَرَاع المَلِك (the cubit of the king), namely one of the Kisrāhs (Mgh, Mṣb,) not the last of them, whose ذِرَاع was seven قبضات (Mgh:) (see also 'مِيل ; it is also an astronomical mesaure, and as such it seems from several instances in which it is mentioned by Kzw and other writers to be, probably, by rule *two degrees*; nearly the half or quarter of the length assigned in different instances to the "رُمْح'; but like the latter, not precise nor unifrom in every instance) ...... It seems from what follows that شِبر (pl. أشبار) is a span.

s. v. رُمْحٌ

a spear; an astronomical measure said to be 1/80th of a circle or 4½° but also seems to be in modern times 9°; said to be equal to 12 spans or اشبار and also 5 cubits.

From THE ENCYCLOPÆDIA OF ISLAM.

ABBASI. Persian silver coin stamped by Abbas I., divided into 2 Mahmudis towards middle of the 17th cent. worth 97 centimes. 50 A = 1 Tomān. In 1660, 5 Abbasi = 9 Livres. In 1806 Abbasi was an imaginary coin.

NUMBERS and TECHNICAL *Arithemetical Terms*, connected therewith.

عدد "A'DAD" *i.e. number*, of 3 series (Marātib مراتب) *viz.* units (āhād, آحاد, pl. of احد), tens ('asharāt عشرات), hundreds (mi'āt مئات, pl. of مائة); 1000s (ulūf الوف pl. of الف) not in series. Numbers absolute muṭlaḳ (مطلق) and saḥiḥ (صحيح) or relative to any assumed unit (Muḍāf ilā mā yufrad wāhidān), and consequently a fraction (kasr كسر , pl. kusūr كسور kusūrāt كسورات). The assumed unit is the denominator (Ma*khradj* مخرج). Musaṭṭaḥ ('مسطّح') = product of a number multiplied by another; Murabba 'مربّع' = product of a number mult. by itself; if product be of 3 factors (mudjassam مجسّم' *e.g.* 3 × 4 × 4); if also all the factors be the same then cube (muka'ab 'مكعب').

In the simple product each factor is ḍil'a ضلع (rib); in that of the square (each factor) *Djidhr* جذر (root), the number itself being therefore ma*djdh*ūr (مجذور).

Even number = Zawdj زوج ; Odd = Fard (فرد). Division by two (Al-tansīf التنصيف). A power of 2 is Zaw*dj* al-zwa*dj* (زوج الزوج); if not it is zaw*dj* al-fard (زوج الفرد). [According to Al-Biruni Zaw*dj* al-zaw*dj* (زوج الزوج) are evenly even numbers *viz.* those which can be divided into halves, and each half into halves and so on repeatedly until the quotient is one; and zaw*dj* al-fard (زوج الفرد) is unevenly even number which admits once of division by two, yielding an odd quotient, not one, like ten: and 'Zaw*dj* al-zaw*dj* wa'l-fard' are evenly odd numbers which admit of being divided into halves more than once, but the division does not extend so far as to yield a quotient of one, like twelve: and 'fard al-fard' is oddly odd number which is divisible by an odd number, with an odd number as quotient; such as nine which is three into three, or fifteen which is five into three, or three into five. Al-Biruni, Ttlm. p. 35.] Prime number Al'adad al fard (العدد دالفرد) or Awwal

Fard (اول فرد). Compound number Al-‘adad al-murākkab (العدد الراكب). Murākkab is also used for a number containing 2 or 3 of the Marātib, *e.g.* 15 in opposition to Mufrad (single). Rational number is = Manṭaḳ منطق; irrational, Asamm اصم (mute). The 9 fractions 1/2 to 1/10 are called “rational, all others “mute”. $\sqrt{121}$ is rational, and $\sqrt{2}$ irrational. Naṭiḳ نطق also = rational root. A whole number represented by one of the rational fractions **1**/2 to 1/**10** is Manṭaḳ al-kasr (منطق الكسر).

When a number is equal to the sum of its divisors *e.g.* 6 = 3 + 2 + 1, it is Tāmm (تام) or Mu’tadil (معتدل) or Musāwi (مساوی); if it is greater than the sum of its divisors, *e.g.* $4 > 1+2$ (*i.e.* 3) it is Nāḳis (ناقص defective); if it is less then the sum of its divisors, *e.g.* $12 < 1 + 2 + 3 + 4 + 6$ (*i.e.* 16), it is Za’id (زائد).

When two numbers have the sum of their divisors equal, they are Muta’ādilān (متعادلان), *e.g.* 39 and 55; the sum of the divisors of 39, 1 + 3 + 13 = 17, and of 55; 1 + 5 + 11 = 17.

When two numbers have the sum of the divisors of each equal to the other number itself, they are Mutaḥābān (متحابان) *e.g.* 220 and 284; for the sum 1 + 2 + 4 + 5 + 10 + 11 + 20 + 22 + 44 + 55 + 110 (of the divisors of 220) = 284, and the sum 1 + 2 + 4 + 71 + 142 (of the divisors of 284) = 220.

Numbers in natural sequence are called Al-‘adād al-ṭabi’iya (العداد الطبيعيه) or al-mutawāliya (المتواليه). Series of odds like (1,3,5,7...) are known as afrād-muttawalih (افراد متواليه) and of evens (2,4,6,......) azwādj muttawālih (ازواج متواليه).

Hindu Arithmetic الصفر (as-ṣifra) *i.e.* the emptiness (शून्य) (*cf.* Eng. cipher)

Series with increasing differences (Al-a’dād al-musaṭṭaḥa العداد المسطح or al-suṭūḥ السطوح)

If the differences are 1, 2, 3, 4 etc. so as to make the Series 1, 3, 6, 10, 15, .. it is Mu*th*all*th*āt (مثلثات); if the differences are 0, 2, 4, 6 etc, and the series 1, 4, 9, 16 ... it is Murabba‘āt (مربعات); if the differences are 0, 3, 6, 9 ... etc. and the Series be 1, 5, 12, 22 etc, it is Mu*kh*ammasāt (مخمسات). From the Musaṭṭa-hāt result by amplification the Mu*dj*assamāt (مجسمات). ?

[This para seems to have been so compressed that the sense does not come out clearly here. The different kinds of series, with differences, of ones, twos, threes, etc. in natural numbers viz.

(i) 1, 2, 3, 4, 5......difference of ones,
(ii) 1, 3, 5, 7, 9...... ,, of twos,
(iii) 1, 4, 7, 10, 13.. ,, of threes,

result in the compound series :—

(i) 1, 3, 6, 10, 15......... = S_1 (mu*th*allathāt),
(ii) 1, 4, 9, 16, 25......... = S_2 (murabba'āt),
(iii) 1, 5, 12, 22, 35......... = S_3 (mukhammasāt) and
obviously $S_1 + S_3 = 2\ S_2$

This is obvious to a student of Algebra who has studied the subject of summation of Series by the method of differences.]

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